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Road in the Ahmadwam sector.

More roads (Waziristan, 1937) - Ahmadwam sector

MORE ROADS (WAZIRISTAN, 1937).

By MAJOR A. E. ARMSTRONG, M.C., R.E.

IN *The R.E. Journal* of June, 1938, appeared an article by Col. R. L. Bond, C.B.E., D.S.O., M.C., describing the construction of the Khaisora road, November, 1936–January, 1937. The operations and the engineer work described therein were but the prelude of the further high adventures in Waziristan in 1937. In January of that year a settlement was concluded with the Tori Khel; troops other than normal garrisons were withdrawn; H.E. the Governor of the N.W.F.P. resumed political control on the 1st February, and the country appeared to be returning to a state of quiescence. It was the lull before the storm.

That "turbulent priest"—The Faqir of Ipi—intensified his propaganda campaign against the Government and in spite of political pressure and limited air action directed against the tribes under his influence—Tori Khel and certain sections of Mahsuds and Madda Khel—the number of outrages perpetrated in the next seven weeks and the raids into administered territory left no alternative to the resumption of operations on a large scale. Consequently political and air control were again vested in the G.O.C.-in-Chief, Northern Command, and preparations for the coming campaign were at once commenced. The normal "peace-time" garrison of Waziristan—Bannu, Razmak, and Wana Brigades—was organized as a Division, thereafter referred to as Wazdiv. As normal road communication with Wana had been interrupted, the brigade there was confined to its own area and the Division for practical purposes was only at two-thirds strength. By April 29th, the 1st Indian Division had concentrated at Mir Ali, and these two Divisions were formed into a force, known as Wazirforce and commanded by the Army Commander.

A few preliminary remarks may assist a proper appreciation of the difficulties—tactical and technical—which were encountered in

the operations. The villain of the piece—the Faqir—has already been described in Col. Bond's article. In addition to exercising a remarkable, indeed an unaccountable, influence over the tribes of Waziristan, Ipi displayed sound strategical knowledge in the selection of his headquarters. He usually occupied a cave area immune from air action and always located more than a full night's march from the nearest striking force. Here, guarded by piqueted approaches, he could harangue his followers, distribute money and supplies and send forth his emissaries to preach the gospel of hate against the Government. The area in which the operations took place is roughly enclosed by the Bannu-Razmak-Tank-Bannu road. This is a good tarmac road. The map on page 13 shows other unmetalled roads in the area radiating from Bannu and also the road constructed in the Khaisora operations. The area varies from flat, sandy, boulder-strewn plain or cultivated land in the East to barren, contorted, precipitous, rocky hills in the centre and hills of more regular outline in the West, still precipitous and laminated, but bearing mostly a dense covering of stout holly oak. The main streams—Tochi, Khaisora, Shaktu and Tankzam—and a few springs provide the only permanent sources of water. The country, therefore, was difficult and the arch-enemy elusive.

The object of the operations was, of course, the re-establishment of order in Waziristan. To effect this, the first essential was to destroy all enemy opposition, reopen all communications, and finally to construct new roads and thereby facilitate military control of such parts of the country as had proved most turbulent. At the beginning of the operations the C.R.E., Waziristan District, had at his disposal only the normal "peace-time" staff of the M.E.S. There were G.E's at Bannu, Razmak and Wana. In addition there was a G.E., New Construction, at Wana (see Col. Bond's article in *The R.E. Journal* of March, 1937) with 3 Field Companies and 1 A.T. Company S. and M. to assist him. One Field Company was stationed at Razmak and was in process of being relieved when operations began.

The normal task of the Garrison Engineers was the maintenance of all military roads and buildings in the area and the maintenance of various large Scout posts and the R.A.F. station at Miranshah. As the situation deteriorated, the movements of G.E's and supervising staff were necessarily restricted and work on road maintenance came to a standstill. But the influx of large reinforcements created more than a compensating demand for their services. The hot weather at such stations as Bannu, Mir Ali or Tank is unusually severe, and it was obvious that very heavy demands for extra accommodation and amenities for troops would have to be met, which would alone fully absorb all the surplus energy and time of the M.E.S. staff.

The C.R.E., Waziristan District, was relieved of all direct responsibility for "peace-time" services and became C.R.E. Wazirforce. There was also a C.R.E. for each Division and later a D.C.E., Wazirforce, was appointed. Initially, 6 Field Companies and 1 Divisional Company, either available in the District or arriving with the 1st Division, formed the Engineer units of the force. 15th Field Company, which was about to return to Bangalore from Razmak, was unkindly detained "for the duration." 12th Field Company—the relieving unit—found itself rudely flung into battle on arrival. 4th Field Company and 43rd Divisional Company arrived up from Rawalpindi, fresh with the 1st Division, and 2nd Field Company was interrupted in its mass production of concrete blocks at Wana to join 1st Division also. Roorkee had generously provided 3rd and 5th Field Companies by May; and in July the G.E. New Construction, Wana, realized there must be a serious war on somewhere, when 14th and 19th Field Companies were removed from him to assist in the operations, and work on the Wana project came practically to a standstill. His reaction was to arrange a leave programme instead—not so easy, either, as Wana's only means of communication with the outer world was by air. The intensive road programme created a demand for further aid; and in August four Road Construction Battalions were raised. No. 1 was raised at Rawalpindi, No. 2 at Peshawar, No. 3 at Lahore—all three 915 strong, composed of good *cis*-Frontier coolies. No. 4 was raised in Waziristan, composed of mercenary and nonchalant Mahsuds, 600 strong. It is impossible in the scope of this article to give even the briefest account of the varying fortunes or activities of these units. The experiences of 15th Field Company, described by Major E. H. T. Gayer, in *The R.E. Journal* of September, 1938, are more or less typical of the work in which Field Companies were engaged during the operations. It is to be hoped that other Field Company Commanders will follow suit and give an account of the work of their respective units during those stirring times. For they were called upon to perform the most varied tasks. Culverts and bridges had to be rebuilt or repaired; pill-boxes and block-houses erected, and camps supplied with water. Assistance from S. and M. in erecting ice factories was required, largely for issue of ice to armoured cars and tanks. Cattle pens for the ration on hoof had to be tactically sited. Brigades on column had to be assisted in demolition of enemy towers, erecting camp piquets, making tracks, and in erecting wire screens over piquets as a protection against bombs. Then came the culminating work of road making and supervision of large working parties and, finally, the erection of two large Scout posts.

Equally varied were the tasks of the M.E.S. Four landing grounds had to be constructed or enlarged. (An article on the Mir

Ali landing ground, which is typical of the work involved, appeared in *The R.E. Journal* of September, 1938.) About 500 tents had to be "chuppared", one-ton ice plants and cold storage installed at Mir Ali, Razmak and Wana, small block-houses erected at various places, bath houses erected, and practically all the other tasks specified for the Sappers and Miners also devolved on the M.E.S., except accompanying columns, but including the construction of cattle pens to preserve the cherished goats and sheep. Goat raiding became a favourite diversion of the local inhabitants during the operations. The staff of the M.E.S. had to expand rapidly to cope not only with emergency work in providing normal services for increased garrisons, but especially with the work of constructing the new roads.

In order to make the road programme comprehensible, a very short survey of the operations is necessary. A trial of strength with the 1st Brigade of the 1st Division near Biche-Kaskai on April 27th–28th and the approach of the hot weather induced Ipi to withdraw his forces from the lower reaches of the Khaisora to the cooler regions near his Headquarters in the caves at Arsal Kot. In May, therefore, Wazdiv. concentrated at Dosalli (less Wana Brigade). After a most carefully planned and completely unexpected night advance of some six miles over one of the sharpest knife-edged crests in Waziristan, involving an ascent of some 2,000 feet en route, Coronation Camp was established by Bannu Brigade on Sham Plain on May 12th. Successive forward bounds over much easier country were made to Ghariom and Pasal camps and from the latter issued the column with which two Field Companies spent one glorious day in thoroughly demolishing the larger caves at Arsal Kot. Ipi had long fled from his salubrious subterranean retreat, but his followers had left in their caves literally legions of fleas, among which there must have been a high percentage of casualties when three-quarters of a ton of explosives brought the house down about their ears. This expedition rather discredited Ipi and ended what may be regarded as the first phase of the operations. Thereafter, though there were many hostile gangs to be challenged to battle and some sharp encounters took place, until October 15th the time and energy of the troops were mainly directed to road making. 1st Division relieved Wazdiv. in Sham Plain on June 1st, and Wazdiv. concentrated in the Razmak area. Meanwhile, the main Razmak road, which had been badly damaged between Dosalli and Razmak, was opened to traffic by the combined efforts of S. and M. and M.E.S. The closing phase of the operations from October 15th to December 15th, took the form of a winter "shoot" by 1st Division in the Bhittani country, followed by some road making there in one of the most earthquake-distorted regions ever experienced.

The second phase (June to October 15th) may be regarded as the "Sappers" phase. Its initiation was due to the intention of the Army Commander to construct roads suitable for the military control of the disturbed area. Early in the operations he called for an estimate, commensurate with his plans, to be submitted as soon as possible. The only means of giving such an estimate was experience, previous costs of similar roads, a map of very doubtful integrity with guess-work contours, air photos, and a map-measurer. The map-measurer was propelled along the possible alignments, 50 per cent for ruling gradient was added for luck, and the cost of Rs.30,000 (£2,250) per mile applied to the result. This cost was arrived at partly from costed average cross-sections and largely from results on the new Wana-Razmak road. The final result submitted to the Government of India for sanction was 82 miles of road, costing 25 lakhs or £187,500. The G. of I. rose to the occasion, and on May 22nd sanctioned the scheme. A further claim on official generosity amounting to 6 lakhs (£45,000) was later made to cover certain roads constructed in the third phase and this again was graciously conceded. The detailed estimates, however, demanded by G. of I. could hardly be accurate, as no one, even from the air, could state definitely where certain roads were going to start or end, or the route they would follow.

The idea behind the 25-lakh scheme was a north-and-south road from Dosalli to Ahmadwam (near Sararogha) and an east-and-west road from Razmak area to the Khaisora area. The final result made Ghariom the meeting point of these two roads, with branches of almost equal length radiating from it towards the four cardinal points and meeting the central Waziristan road at Ahmadwam, Razmak, and Dosalli and the Khaisora road at Biche-Kaskai. Work was first started from Dosalli to Madamir Kilai (19 miles) on June 7th by 1st Division. Three weeks later, work on the opposite end—Ahmadwam to Madamir—some 20 miles—was started by contract labour under the protection of the South Waziristan Scouts. The Dosalli-Madamir Kilai section was completed by August 12th. Work on the other end was delayed by the tardiness and truculence of the 216 petty Mahsud contractors, as well as by the many heavy rock cuts in the alignment, and this section was not completed till December 15th. The honour of turning the first stone on the Razmak-Ghariom section—some 22 miles—fell to 12th Field Company on July 10th, and thereafter Wazdiv. gave Razmak and Bannu Brigades alternately the job of completing the first five miles under S. and M. supervision, combining road making with occasional "days in the country" after hostile gangs. Ahead of that, 18 tribal contractors and 3 down-country contractors worked up to mile 12, supervised by M.E.S. operating from two forward camps formed by Scouts or

regular troops. Meanwhile 1st Division, having completed its first section to Madamir, turned its face westwards, formed two forward camps in succession and, hurling any infantry which could be spared from protective duty, and three R.C. Bns. and finally its Sappers and Miners, into the work on the opposite end, completed it to meet Wazdiv. at mile 12. Before Wazdiv. had quite reached that point 1st Division, as has been previously indicated, went off on its excursion into the Bhittani country. On November 20th, though there were still a few incomplete portions on the Ahmadwam section, H.E. the Governor and the Army Commander motored from Ahmadwam to Razmak *via* Ghariom, and Wazdiv's task was over. Meanwhile the eastern branch from Ghariom to Biche-Kaskai—some 21 miles—was receiving attention. Work was started at both ends. On August 14th, a Field Company S. and M. and one R.C. Bn. started work from Ghariom, while on August 29th, work was started farther ahead by M.E.S. and contract labour under the protection of Scouts. The number of tribal contractors on this section was the lowest on record—fifteen; and these, in return for officially stipulated honoraria, waived "the right to work," and two selected down-country contractors completed the section to meet the S. and M. and the R.C. Bn. The whole branch from Ghariom to Biche was completed by November 17th. Thus, by mid-November, the originally planned road programme was practically completed, and the main "Sapper" phase ended.

But there were more roads to come. For the control of the Bhittani country another road was required—20 miles in length—from Tajori in the administered territory to Kot Fort in Bhittani territory. Early in the campaign the P.W.D. had co-operated by improving a portion of the road forward of Tajori and from this point (Nungar Tangi) to the border of tribal territory—2½ miles—the work was undertaken by down-country contractors under M.E.S. supervision. Work was commenced on October 16th and completed in a short time. From the tribal border to Kot—10½ miles—the work was undertaken by 1st Division simultaneously with the operations there. The tribal contractor who had been nominated for this portion proved a non-co-operator; so, to ensure completion to time, an extra S. and M. Company, three R.C. Bns. and all available road machinery were drafted to 1st Division. Not only was the country almost deserted and rock-bound and unsuited to the making even of a passable goat-track, but winter and preparations for evacuation were pressing. The pace was forced and the road completed to Kot by December 2nd.

Meanwhile, certain lateral communications were not considered satisfactory. Approval and funds for two more short roads were demanded from G. of I. G. of I. readily granted approval but could not find the money. Hence, nine more miles of road were demanded

from C.R.E. Wazirforce on a "no-cost" basis, and two and a half of them in hair-raising country. These 2½ miles called "the Shaktu spur," leading from the Ghariom-Biche road towards the Shaktu valley, were tackled by a Field Company and a R.C. Bn., and completed by November 14th. The remaining 6½ miles from the lower reaches of the Khaisora valley across to the Shaktu valley—called the Rocha-Karkanwan road—were completed by one R.C. Bn. and road machinery on December 14th—just on time. The allotment of 31 lakhs was further strained by a demand of no less than 74,000 rupees (£5,500) for improvements to 15 miles of existing roads, with an eye to improving approaches to tribal territory in future campaigns. Twelve of these miles were in administered territory and might normally be expected to be a charge against provincial funds. But the allotment withstood even this final outrage. So the final result was that from the 31 lakhs (£232,500), 115 miles of new road were built and 15 miles improved within the period June 7th till December 14th.

There is, however, one more road which, though it was not included in the programme of new roads, cannot be omitted from this account of pioneering activity. It is now probably used by wandering camels or tribesmen engaged on their lawful or unlawful activities. It is the road which was constructed from Dosalli to Coronation Camp in May. It was the first experience of most of the troops in road making. Supplies for the newly formed camp had to be sent by air or, later, by pack transport and the necessity of constructing a M.T. track to camp was obvious even to the most obtuse. Work was most enthusiastic. It was here that the S. and M. of Wazdiv. first assumed charge of large infantry working parties, and 13 miles of M.T. track were completed in 17 days, eventually extending to Ghariom camp, and overcoming an ascent of 1,000 feet through hard scrub-covered country *en route*. This was purely an "operations" road, and the new road eventually constructed to Ghariom followed a different alignment.

Mention must also be made of the passable M.T. tracks, which S. and M. sponsored in connection with various unnamed operations. They had eventually logged no less than 26 miles of such track, of which both written record and physical trace are now being rapidly lost but which absorbed no small amount of energy in construction.

Towards the close of the operations in November a more interesting task was allotted to S. and M. It had been decided to build two semi-permanent Scout posts in the pacified area. One was sited at Ghariom and the other at Biche. The skilled labour in each case was supplied by S. and M., and working parties were provided by R.C. Bns. or infantry. The work was commenced in the beginning of November and completed by the second week of December. The extent of the task can be gathered from the fact

that each post was designed for 12 platoons of Scouts and a reserve of supplies for a Brigade for 3 days. The posts were surrounded by two belts of wire and 1,200 yards of perimeter wall. The buildings for accommodation of the garrison inside were built in 18-inch stone masonry. In addition, four reserve water tanks in R.C.C. of 12,000 gallons each were installed, fed by a mechanical pumping set against a 25-foot head.

Water supply was always a difficulty throughout the whole campaign. Two water supply projects deserve special mention. The first was the supply to Dosalli. The normal supply to the permanent Scouts' post there had to be supplemented as soon as Wazdiv. concentrated there. The nearest permanent source was at Dosalli village, 2½ miles up the *nullah* to the South. This length of 4-inch Victaulic piping was laid complete in one day by two sections S. and M., assisted by a mixed working party of 200 infantry and 50 coolies. The line was later extended and improved and supplied 6,000 gallons per hour. A bigger problem was the supply of water to the four successive camps formed during the construction of the road from Ghariom towards Biche. The source was a *nullah*, one mile from Ghariom camp and 450 feet below it, where a 5-stage Tangye centrifugal pump was installed, pumping through 4-inch Victaulic. As work progressed and forward camps were formed, this line was extended normally by the shortest route between camps, suffering many violent changes of level between. The greatest difference of level amounted to 1,000 feet between the highest point of the line, which was a reservoir on a crest near Ghariom, and the point of supply. The ground was generally steep, rocky hillside, and it was impossible in the time to lay the pipe with a uniform gradient. Nevertheless, over the eventual 11 miles of piping, air locks were infrequent and the abnormal pressure never proved disastrous. Stranger still, the tribesmen showed remarkable lack of initiative in causing damage to the pipe over unprotected sections of the line. The difficulties of laying heavy lengths of pipe, often almost red-hot, in such country to new camps ahead of the M.T. track, can be well imagined as also the difficulty of rapid dismantling, both of which tasks had to be detailed operations of war. In addition to serving the garrison at Ghariom, this line had to supply 1 Field Company, 2 R.C. Bns., and 500 Scouts at the camps ahead and an additional 2,000 coolies at the last camp. Luckily, the coolies largely regarded water as a means of relieving thirst only.

The most important engineer problem, however, had been the construction of the new roads in accordance with the Army Commander's plans. He specified a fair weather motor transport road. The detailed specification given by C.R.E., Wazirforce, was a 16-foot clear width natural soil track. This width had to

1.—The first road. Dosalli to Coronation Camp.

2.—The Razmak area.

More roads (Waziristan, 1937) - 1 & 2

3.—A road builder at work.

4.—Practically the "finished article."

More roads (Waziristan, 1937) - 3 & 4

be increased 50 per cent on curves. The final surface was to be shingle, 12 feet wide and of depth 1 inch to 3 inches according to soil. The minimum radius of curves was to be 35 feet centre line, though eventually this had to be increased to 50 feet for satisfactory results with the smaller lock vehicles. The ruling gradient was to be 1 in 17½, eventually increased, partly for financial reasons, to 1 in 15, which was found quite satisfactory. The minimum of retaining walls and culverts were to be erected, though, in a few cases, a few short span bridges had to be made. (See *R.E. Journal* of December, 1938.) Culverts and bridges, with a view to minimizing subsequent sabotage, were to be R.C.C. and all masonry work in cement mortar. Side and catch-water drains were specified, and, for cross drainage, one stone surfaced scupper per furlong.

Primed with these instructions, the Field Engineers had to lay out the alignment. The usual procedure was, first, roughly to align the road from air photos, then correct ideas by an air reconnaissance, followed by a ground reconnaissance with any mobile column operating in the area. By this means ruling points at least would be ascertained and the relative merits of alternative routes assessed. The rough alignment was always fairly certain 5 miles ahead of work and the detailed alignment one mile ahead. At first, each officer had his own particular method of hasty lay-out but eventually the method became standardized. The Abney level was used for long "shots" to fix ruling points definitely. This was no easy task when the officer found himself in thick holly oak jungle with sweat and thorns running between shirt and skin and visibility reduced to two yards! By clearing where necessary, or use of gay bunting carried aloft on long staves, the mutual accessibility of ruling points, with or without zigzags, was ascertained and trial *burjis* (small cairns) made at intermediate points. Afterwards, the alignment was cleared where necessary and the Abney level and staff were used to fix the detailed alignment, and such level marks or pegs fixed as could not be easily removed or misunderstood. The succeeding work of marking the upper cutting edge on the hillside for the first 6-foot track and, later, the cutting edge for the full width of the road was easy by comparison. Afterwards, walls and scuppers were laid out in detail, mile and furlong stones placed and an accurate line of levels laid. The common errors in lay-out arose from neglect of the fact that scuppers and curves must be flat and a decrease of 5 to 10 per cent made in the overall ruling gradient where they are frequent. Another error arose from lack of accuracy in marking the final cutting line so that the "fill" could be most economically used. It was also found that, where S. and M. were not available for supervision, detailed level-marks were required every 30 feet. Many a R.E. officer groaned to see his carefully laid level-marks buried or demolished by nonchalant

tribal contractors or unsuspecting infantry. One interesting principle emerged from protracted discussion at the time the final alignment of the road from Dosalli to Ghariom was being fixed. It was decided that though the road should be aligned so as to tap villages and where possible be kept at a distance from disputed inter-tribal boundaries, yet from the point of view of protection and subsequent maintenance, the alignment along the watershed was in all cases preferable to an alignment following the valley. The best alignment, however, from the engineering and tactical point of view, could not always be adopted if political considerations necessitated the selection of a different route.

Apart from engineer units, work on road construction was, as previously indicated, carried out by four main agencies, viz.: infantry, R.C. Bns. contract labour and machinery. Of infantry, the maximum number at work on any one day was 6,136, and the average was 3,400, and the total military man-hours reached 1,886,340. Not only did this create problems of organization of work, supply of tools, etc., but the financial repercussions of working pay had also to be considered. Road construction was always an operation of war, contrary to anticipated conditions, and so the number of infantry on work and their hours of work were necessarily restricted. Though the infantry took kindly to this modern form of *corvée*, they were found both slow and expensive. This created a demand for the 4 R.C. Bns. Of these, 3 were commanded by R.E. officers. The fourth (Mahsud) for lack of a Pushtu-speaking Sapper was commanded by an Indian Infantry officer. These units were most effective on the job but were a financial failure, as every item of expenditure connected with them—pay, clothing, food, transport —had to be debited to the road fund, and they were not raised in time to prove an economy *vis-à-vis* contract labour. Combined with S. and M.—usually one Company per Bn.—these units were efficient and quick, and, as no supplementary M.E.S. or civilian staff is required for them, they fit into active service conditions better than contract labour. It was found that one R.C. Bn. can produce a working party equivalent to that which could be found from a Brigade finding its own protection.

Contract labour varied immensely. Political authorities wanted to nominate numerous petty tribal contractors. These proved slow, rapacious, and quarrelsome, and showed a tendency to " down " tools or even commit acts of flagrant sabotage if advances of pay were not regularly given. A contractor was frequently nominated for a few hundred feet of road and the total labour in one such instance amounted to the head of the family, his son and a pair of grandsons. Considering their normal risk of being shot by their next-door neighbour, they might well be regarded as erecting a family memorial. But time was short and construction

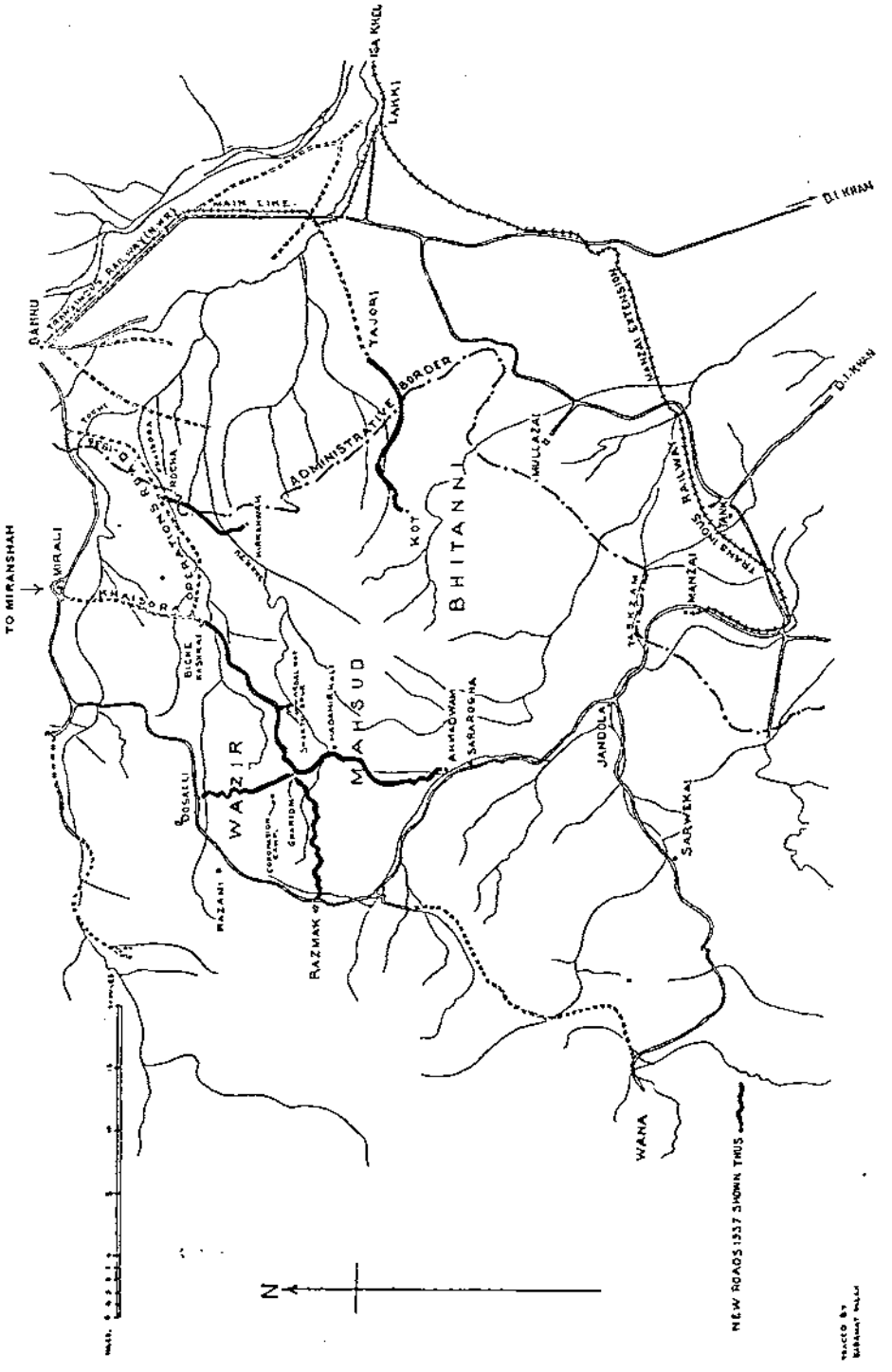
by this type of contractor could not be allowed to continue. Hence selected down-country contractors were, after pressure on political authorities, introduced. As the hours of labour for the down-country coolies had to conform to the hours of the protecting troops, and their camps had to be close to the military camp, hours of work were restricted and time was wasted getting to work. Consequently, contractors' rates were high, but at least they all finished work satisfactorily on time, and in the end the down-country contractor proved the most efficient and economical means of road construction.

At the beginning of the operations, there were in Waziristan, 1 road-builder, 2 graders, 1 auto-patrol, 1 scraper and 1 portable compressor. Three road-builders, 11 portable compressors and 1 tractor were purchased during the operations; neighbouring districts were persuaded to send all their machines, and at the close of the operations there were on work 6 road-builders, 3 graders, 2 auto-patrols, 5 of a mixed bunch of scrapers and planers and 23 portable compressors. Normally these machines worked in batteries of one or two road-builders, one grader and one auto-patrol each, working under S. and M. or M.E.S. as required. All machines were staffed by M.E.S. and administered by the Staff Captain (E. and M.), who, with his flying squad of "first aid" mechanists, endeavoured to heal the ravages of time and forced labour on some of the more elderly machines. Experience emphasized the necessity of having skilled supervisors in charge to ensure, not only that the machines were given a task for which they were mechanically suited, but that they were used efficiently to give maximum output. The necessity of having some form of forward workshop was also apparent, possibly in conjunction with the workshop of the Divisional Company, S. and M. Results on the worst road (Tajori-Kot) showed that a battery of 3 road-builders, 1 grader and 1 auto-patrol was equivalent to 1,200 men. In fact, the three new 90-H.P. "monsters" were regarded with suspicion if they could not remove 3,200 cubic feet per hour each in "hard boulder" soil, and if in the hardest type of soil the output fell below 800 cubic feet per hour or below 500 for the 50-H.P. type, the machines were sent back to rest and the work undertaken by manual labour.

As the operations neared the end, not only was all possible use made of any available men or machines for road construction, but the financial control of the road budget grew even more rigid. Indeed, the situation of the road budget had been an anxiety from the very beginning. It was first believed that roads would be built only on conclusion of a successful campaign, that "peace-time" contract rates would obtain, and that troop labour would be available for half the programme. None of these assumptions was realized, and contract rates were 10 to 25 per cent above

normal. Then the road estimate had to meet all sorts of charges—protection, water, transport, machinery, working pay, every item of cost of the R.C. Bns.—in fact, any and every charge that with any degree of justification could be debited to it. It was realized that certain drastic steps would have to be taken to reduce expenditure. Any R.E. officer found using guncotton in order to avoid the labour of jumping a hole for gelignite incurred passing displeasure. The shortest alignment consistent with the easiest route was chosen. Retaining walls, culverts and scuppers were reduced to a minimum and, in really stiff rock-cuts, variations from the original specification were welcomed rather than disapproved. Financial control could only be maintained by regular daily reports. Every R.E. officer forwarding his daily progress report, in addition to showing progress on his portion of road, had to show any possible source of expenditure arising that day, *e.g.*, explosives, working pay, P.O.L., hired transport, departmental labour on work, etc. This strict control had its reward, and, in spite of all the surcharges the road estimate had to bear, it survived the strain. As a result of these daily reports and the collected experience of officers on the work, certain data were compiled and the more interesting facts and lessons are shown in the appendix to this article.

This article would not be complete without a reference to the M.E.S. ancillary services, working in the heat, dust, and recurring alarms at Bannu. The most important part of the rear organization was the Waziristan Base Engineer Park which was eventually located there. A.C.R.E. (E. and M.) Waziristan District, became the officer-in-charge of all engineer stores required for the operations. The first intimation that other districts received of the impending summer campaign in Waziristan was a series of urgent telegraphic demands for "chupparing" stores. The bazaars of the N.W.F.P. and parts of the Punjab were scoured for *bullis*, nails and wire. The arrival of these, and other bulky stores and the eventual scope of the operations, led to the need for expansion of the Park area and eventually a new Park, covering 3½ acres, had to be built. The sources of supply of stores varied from Engineer Parks in Northern Command and Quetta, Arsenals and I.S.D., to local purchase in Bannu or anywhere in India for proprietary articles. Stores were dispatched forward by lorry to the five advanced Waziforce dumps, which were manned by M.E.S. personnel. From March 10th to November 30th the total cost of stores issued and labour employed reached 17 lakhs (£127,500), and the maximum amount of stores dispatched on any one day reached 70 tons. There were many difficulties in maintaining the supply of stores. Apart from depletion of reserves, the initial lack of knowledge of the programme, either of operations or road construction, made accurate forecasts of requirements impossible, and not the least


TO MIRANSHAH
MIRALI
KHAISOR
BICHE KASHKAI
BOSALLI
RAZANI
RAZMAK
WAZIR
MAHSUD
BHITANNI
ADMINISTRATIVE BORDER
KOT
TAJORI
LAHMI
DARHU
MAIN LINE
D.I.KHAN
MULLAZAI
TARKLAM
MANZAI
JANDOLA
SARWEKAI
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N
NEW ROADS 1937 SHOWN THUS

of the difficulties was the fact that from 13·00 to 17·00 hours daily in the hot weather the stores were too hot to touch.

The second over-worked link in the rear organization was the M.E.S. workshops at Bannu. This was also under the control of the officer in charge of the B.E. Park. Here two shifts were worked daily from mid-May until the close of the operations. The most useful plant in the workshops was the electric welding plant, which succeeded in repairing even broken axles of 3 to 4 inches diameter. Road-building machinery which could not be repaired by the forward "first aid" squad was restored to serviceable condition, though some of the older machines required considerable coaxing back to life. Three 50-H.P. road-builders were completely overhauled, pumping machinery tested, 750-lb. ice boxes manufactured, and innumerable miscellaneous jobs performed amounting in all to the value of Rs.60,000 (£4,500) excluding the cost of materials.

The last link in the chain of the rear organization was the M.E.S. Depot. This developed from a part-time officer and half a clerk to three clerks and a typist. It acted as a clearing house for all technical, clerical and menial personnel temporarily transferred from other districts or engaged for the operations. It eventually bore on its books 563 men of all grades and trades—clerks, store-keepers, overseers or work *munshis*, masons, engine-drivers and sweepers. Men of the two latter professions were particularly hard to find. All personnel on the Depot strength were paid on the Pay Book system and their accounts were maintained by the Depot unassisted by any accounts staff. In addition to struggling with the issue of passes, arm-bands and pay-books, disputed pay claims, and audit objections, the Depot was practically an employment exchange. It occasionally incurred the odium of Field Engineers if the tradesmen it dispatched forward were of poor quality, but the real difficulty lay in the fact that it was a purely "war-time" organization and the staff had to be improvised of clerks who had no experience of pay duties. However, it performed a noble task and still survives to settle a few belated pay claims and to distribute medals to those who carried its arm-bands to the forefront of the battle.

Finally, this article has been framed not merely to describe the extent and nature of the engineer tasks arising during the operations and the difficulty of executing them within the limits of time and money prescribed, but also to be of assistance to the officer, whether of exalted or junior rank, who finds himself all unsuspectingly involved in the high-pressure activity of one of these perennial "shows" on the Frontier.

APPENDIX.

A. LESSONS.

(1) All bridges should be provided with close protection pill-boxes, and have a serviceable diversion.
(2) S. and M. detachment accompanying a column should be of absolute minimum strength.
(3) A study of air photos is most valuable before any form of reconnaissance, and all R.E. officers should have practice in peace.
(4) Compressors require a high proportion of the pick and spade tools in addition to their boring tools.
(5) For carriage of piping or road metal, Government 30-cwt. or 3-ton lorries are unsuitable. The hired 3½-ton truck with drop sides and a movable " hump " is most efficient.
(6) R.E. officers require peace-time training in submitting intelligence reports.
(7) Training in high-speed laying of Victaulic piping is essential.
(8) Necessity for a C.R.E's pool of transport on the lines of the " home " organization.
(9) Where coolie camps are formed in the area of any formation, they should be administered and rationed by the formation concerned.

B. DATA.

(1) *Transport.*
Normal daily requirement by R.E. for all purposes in 3-ton lorries 62

(2) *M.T. Tracks* (10–12 feet wide, 9 feet cut).

Cut difficult	4,000–5,000	man days per mile
,, easy	800–1,000	,, ,, ,, ,,
Plains	100– 200	,, ,, ,, ,,

(3) *Demolition of Towers.*
Solid masonry plinth 15 feet by 15 feet up to 40 feet height :—
48 lb. guncotton buried centrally.

(4) *4-inch Victaulic piping.*
2 fitters and 8 coolies lay 600 feet per hour.

(5) *Chuppars.*
7 carpenters and 11 coolies, 12 hours per chuppar.

(6) Cost of R.C. Bn. for 4 months (800 men, 120 days).
2 lakhs (£15,000).

(7) Man hours per mile of road.

Tribal labour	106,430
Military (including R.C.B's)	81,870
Down-country labour ...	82,450
Machinery crew	4,500 (with 273 machinery hours)

Average labour per mile, 87,000 man hours.

(8) On a road suitable for machinery, the machines can do 60 per cent of the work, and 40 per cent manual labour is required for walling, blasting and shingling.

(9) A battery of road machinery (3 road-builders, 1 grader, 1 auto-patrol) produced on the worst road the equivalent of 52,000 man hours in 43 hours.

(10) Average speed of road machinery "on hoof" varies from 2 miles per hour on broken ground to 5 miles per hour on smooth level ground.

C. TOTAL ISSUES OF IMPORTANT STORES FROM B.E. PARK.

Victaulic piping 1-inch	Foot run. ...	10,756
,, ,, 2-inch	,, ...	26,000
,, ,, 3-inch	,, ...	89,000
Corrugated galvanized iron sheets	... ...	6,479
400 gallon tanks	... ...	160
Army track	Coils of 25 yards	468
Crowbars	No.	910
Hammers, sledge	... ...	1,900
,, stone breaking	... ...	680
Axes, pick heads	... ...	14,600
,, helves	... ...	30,600
Shovels, complete	... ...	18,000
,, spare helves	... ...	4,700
Tanks, canvas, 1,500 gallon	... ...	148
,, 50 gallon...	... ...	312
Troughs, canvas	... ...	97
Tapes, measuring	... ...	103
Bars, boring, boring and jumping, and jumpers ...	...	4,000
Pickets, angle long	... ...	68,500
,, ,, short (and medium)	... ...	95,700
Barbed wire	Coils ...	30,600
Sandbags	... ...	435,000
Cement	Tons ...	2,200
Mild steel of various sections	,, ...	92

"CHUPPARING STORES."

Bullis, various	... ...	57,000
Matting, Mizri	Square foot	1,700,000
Nails	Tons ...	17
Galvanized iron wire, No. 8	,, ...	46

The stores chuppared about 600 Indian Pattern tents, and include bullies and matting used for other purposes.

THE NEW FIELD COMPANY, R.E., AT WORK.

By MAJOR D. HARRISON, R.E.

THE year 1938 has seen many changes in organization affecting all arms. As a result of the recommendations of the Finlayson Committee, the Field Units of the Corps of Royal Engineers were reorganized and underwent a major reorganization, and one based to a very great extent on theoretical considerations. Whether the new Company would prove as powerful an instrument as the old remained to be seen when an opportunity arose.

This opportunity was created during the manœuvre period in September, 1938. For the 2nd Division Exercise, which took place on September 7th/9th, the 5th Field Coy., R.E., was brought up to full war establishment within the limits imposed by shortage of personnel and equipment. They also had the opportunity of tackling a real job of work, a complex river-crossing problem, from start to finish. To add to realism, by good fortune and hard work it was possible to arrange for them to be given practically a free hand, much more so than is normally given in peace even with the Manœuvre Act in force. The whole operation thus became exceptionally interesting, and, since few of us are able to serve with Field Units, an account of it is indicated. As far as possible the various stages will be dealt with separately.

PHASE I.—THE TACTICAL PICTURE AND PRELIMINARY WORK.

(*Vide Map, page* 24.)

Southland, to which 2nd Div. belonged, was holding with very great difficulty a line on the high ground about four miles east of the R. Itchen, south and east of Winchester. The line was crumbling under repeated attacks and it had been decided to push in the 4th Gds. Bde. to restore the situation. The permanent bridges over the Itchen were subjected to continual heavy harassing fire, and to air attack, to such an extent that they could not be used at all by day and very little by night. The 4th Gds. Bde. was due to complete mobilization near Stockbridge on the evening of September 7th, and could not reach the western Winchester area before dawn on September 8th. This meant a day crossing of the Itchen, since further delay in their arrival in the line might prove fatal. It was therefore evident that a relief crossing would have to be prepared for them.

Engineer troops belonging to Corps and the Divisions in the line had carried out a general reconnaissance of the area and collected a certain amount of material with a view to a crossing of this nature. A possible line had been found, which might, it was thought, be made into a suitable route.

In practice this preliminary reconnaissance was done by the C.R.E. and Adjt., 2nd Div., R.E., who did noble work in persuading local owners to agree to the temporary mutilation of their property. Also, since peace resources do not contain either the material or the transport necessary for a large-scale bridging operation, it was necessary for collection of material to be carried out in advance by easy stages. The 2nd Div. does not possess a Field Park Coy. in peace, so heavy timber work had also to be done in Aldershot. The design of the bridges, the collection and fitting together of material, and its piecemeal transport on one Scammell and trailer took some weeks, and a great deal of organization and team work.

The secret was carefully kept from the 5th Fd. Coy. The Coy. Comdr. was allowed to make a preliminary reconnaissance, with his C.S.M. only, on the afternoon of September 3rd. No mention of the problem was made to anyone else in the Coy. until mobilization was completed on 6th September.

To complete the tactical picture, the 5th Fd. Coy., which was normally affiliated to 4th Gds. Bde., completed mobilization 24 hours before the rest of the Bde. Group, and departed at once to prepare a crossing for its brigade under the orders of C.R.E. 2nd Div. It was to revert to under command 4th Gds. Bde. on the morning of September 8th.

PHASE II.—MOBILIZATION OF 5TH FIELD COY., R.E.

The Coy. was engaged in a London District exercise with 4th Gds. Bde. on the 5th/6th September, which gave them a fairly busy time and an uncomfortable night. They got back to camp at Popham, between Basingstoke and Stockbridge, coming in piecemeal from 12 noon onwards on the 6th. Detachments from other R.E. units joined that afternoon, and the Coy. paraded at war strength at 6 p.m. A small box-girder set and a derrick lorry from the 6th Fd. Park Coy. (1st Div.) reported at 9.30 a.m. on the 7th, by which time the main body of the Coy. had begun to arrive in the area south of Winchester.

PHASE III.—THE ENGINEER PROBLEM.

(See air photo No. 1.)

The R. Itchen in the area south of Winchester flows in several channels. The ground between these channels is marshy, and, as we

found to our cost in more than one instance, with several subterranean channels rising from springs. The width of the area averages 1,000 yards.

The only possible crossing between Winchester and Compton was on the line of what seems to have been once a monks' road, used by the monks of St. Cross in the days when the whole of the area was a monastery estate. It had long fallen into disuse, and was merely the foundation on which to build.

The route chosen is marked in a heavy dotted line on the map. It took off the main road down a short service road to a sharp turning through a gateway into a field. The gateway was 14 ft. wide, but the available turning space was so small that guns could not get round and one gate post had to come up. Through the field, and under the new Winchester by-pass, there was a good track, coming out of the second field close to an archway under the Southern Railway main line to Southampton. The floor of this archway was very rough, chalky, and slippery. In the centre a piece of iron piping stuck up about 9 in. This could not be moved and had to be cut with explosive.

From the archway into the camp field was a bad turn, and to make it passable a certain amount of road work had to be done, a gate and gate posts taken away, and a piece of barbed wire fence removed.

The first two crossings of the river were so close together that it was necessary to bridge over the intervening piece of ground, and so carry a continuous bridge over a length of 63 ft. Cattle bridges existed, but they were only useful as footbridges, being very light. Just across the bridge two large branches of an ash tree swept down to within 8 ft. of the ground, and had to be cut off.

At C there was another gate, and again one of the gate posts, which was actually a growing whitethorn bush, had to be demolished. From C to D the track crossed a series of ridges which had a channel cut in the top of each—the old feeders to the water meadow. The ground was soft, and a good deal of filling with branches, sandbags, etc., was necessary to make a track that would stand up at all. Even then maintenance on this section was almost continuous.

The crossings at D, E and F presented a very tricky problem in alignment. The only available R.S.J.'s were only just long enough to cross the stream at D at right angles. The small box-girder had to be used over the main river at E, a 48-ft. span. The track from F to G was fixed, the only possible line through marshy ground, and the line of the R.S.J. bridge at F was fixed by the further direction of the track. The position and angle of the small box-girder bridge was therefore a matter of extreme importance since :

(i) Between the bridge D and the small box-girder there could be no turn. Gun teams had the tractor on the small box-girder while the gun was on the bridge at D (*vide* Photo No. 4).

(ii) There was no room for a double bend between the small box-girder and F, nor would the ground have stood a change of direction. Drivers had to come off the small box-girder bridge on half-lock and kept on the same curve until they got on the bridge at F.

(iii) The small box-girder had to be launched from the west side, and there was only a limited area in which there was a reasonable approach. It also had to be on a skew.

The combined result of all these factors was to make the correct siting and alignment of all three bridges a matter of inches; not too easy on a curve over rough ground and three streams.

The bridge at F had to be sunk below the level of the banks to avoid a very bad bump each side. This should have been easy, for at the site eventually chosen there were the brick abutments of an old cattle bridge. Unfortunately it was found that the main flow of the stream passed behind the west abutment, through a tunnel which it had cut during many years. The first discovery of this was made by a corporal who made a hole some 3 ft. across with one blow of a pick, and then fell into it.

The track through the marsh from F to G had a maximum width of 6 ft. 4 in. On the way it crossed two culverts, both of which showed distinct signs of wear before the end of the operation. Just short of G a large willow tree with a trunk nearly 4 ft. in diameter had fallen across the track and gone on growing. It might have been shifted with explosive, but there was a distinct risk of making matters worse than ever and of removing the track as well, so it was decided to cut off the branches and roll the trunk away, after cutting the roots. Eventually this succeeded, after 2½ hours' hard work, and the admiration of the onlookers for a properly-felled tree as an obstacle was only equalled by the exasperation of the working party.

The bridge at G was a straightforward job, another stock span, only complicated by the existence of a very humped brick culvert close behind it. From G to H the track had disappeared in a tangle of reeds, grass, bushes and overhanging branches. At H there was another culvert 6 ft. 6 in. wide, and a gateway that had to be demolished. These two brick culverts gave rise to anxious speculation and scrutiny; it was eventually decided that they might stand up to medium loads, but material was kept ready to strengthen them, and they were carefully watched.

The last serious problem was from I to K, where the track was on a 4-ft. bank, very soft and already deeply rutted. This was dealt with by levelling off and laying army track on hessian over a 50-yard

stretch. The remaining culverts between this and the eastern main road were strong enough to carry medium loads.

Summarized, therefore, the Fd. Coy. Comdr's. preliminary reconnaissance produced the following list of work to be done :—

Seven bridges, six on R.S.J.'s and one small box-girder. 1,500 yards of clearing, including levelling, filling, use of army track, removal of the willow tree, several lots of wheel guides and handrails, removal of gate posts and fences, cutting off heavy branches of trees, marking and notice boarding the track throughout, and decontamination arrangements.

He found on site two dumps of R.S.J.'s and superstructure, which needed sorting out, but did contain enough for the six bridges. There was a little, but not nearly enough, spare timber, so he would have to use what he could cut to supplement it. The army track, which he had asked for after his preliminary reconnaissance, had arrived. To help in transporting material, a pontoon dolly (trolley) was due to arrive from Christchurch at 1030 hrs. on September 7th. This proved to be invaluable, being used to shift all kinds of material including R.S.J's and S.B.G. sections. It is light, portable, and easy to handle over rough ground.

The area was said to be subject to intense air attack. He was not allowed to move from Popham before the morning of September 7th, and the route had to be ready by dawn, 0500 hrs., on September 8th. Popham was 16 miles from the area, and due to the need for secrecy the column would have to move down at a density not over 20 v.t.m. The hired transport and the presence of two 3-ton lorries of anti-tank mines would restrict it to 15 m.i.h. The Coy. had had an exhausting two days on 5th–6th September. No detailed reconnaissance had been done.

It was evident that to get the job done in time would require careful organization, a simple plan, determination and decentralization. Even then, it seemed as if he would also need to be lucky.

Phase IV.—The Organization of Work.

It would perhaps be tedious to go into this in as much detail as was in fact done. Briefly, each section was given a clear-cut task.

No. 1 Sec.—The two eastern bridges, some of the clearing, and the army track section.

No. 2 Sec.—The bulk of the clearing, road-making, and marking, and the small box-girder bridge (which depended on the work of No. 1 Sec. for execution).

No. 3 Sec.—The western bridges, four in all, but of which the first three had to be laid so as to form one continuous bridge.

Only two compressors were available, of which one was allotted to each of Nos. 1 and 3 Secs., No. 2 Sec. having a call on one lead from each. (Their work for which a compressor could be used was conveniently situated.)

It was decided that reconnaissance parties, *i.e.*, section officers in their 8-cwt. trucks, should leave Popham with the O.C. Coy. at 0700 hrs. The main body would move out under the 2nd-in-Comd. at 0800 hrs. They should be in their areas, with all vehicles concealed, by 1000 hrs., ready for work. By this time the Sec. Comdrs. should have finished their detailed reconnaissance.

Hours of work laid down were :—

Work, 1000–1400 hrs.
Dinners, 1400 hrs.
Work, 1500–1800 hrs.
Teas, 1800 hrs.
Work, 1830–2130 hrs. (dark).
Suppers, 2130 hrs.
Night work as necessary, a rest to be given if possible from 2130 hrs. to 0200 hrs. on 8th.

Having worked out section tasks and hours of work, the Coy. Comdr. got down to a private time-table. On this, after several arbitrary cuttings down, he arrived at the following programme for completion :—

No. 1 Sec.—0400 hrs. with rest from 2100 hrs. to 0200 hrs.
No. 2 Sec.—All but small box-girder by 1800 hrs.; small box-girder to be put over, starting at midnight.
No. 3 Sec.—0400 hrs. with rest from 2100 hrs. to 0200 hrs.

The Coy. Comdr. then began to feel that, even allowing for accidents, the job should be done by 0500 hrs. anyhow.

The A.A. guns and crews were taken under company control, and gas sentries were detailed. The H.Q. section took on the decontamination arrangements, erecting both Sportapool tanks and getting ready the centrifugal pumping set. Messing was centralized. An R.A.M.C. officer ran an aid post at Coy. H.Q.

PHASE V.—THE EXECUTION OF THE WORK.

Here again detail is to be avoided. so only broad outlines and some incidents will be given. The Coy. Comdr's. forecast proved to be completely wrong.

The timings started well, and work began at 1015 hrs. The hours of meals were adhered to, roughly, as it proved a little difficult to get section commanders to break their men off. Apart from this, all sections metaphorically not only took the bits in their teeth, they

swallowed them. Unexpected difficulties were swept aside, by everyone from sappers to subalterns, and the entire company sat down to supper at 2115 hrs. with the job completed. Now for one or two incidents.

The threat of air action developed into a most realistic and spectacular affair. Three flights came over at different times of the day, and put in a series of low-flying attacks, which, although they failed to produce casualties, were so brilliantly carried out that they definitely stopped work for 25 minutes each time. These flights all came from some distance and they really seemed to enjoy it. Certainly we are very much indebted to them for a most convincing if somewhat terrifying display.

In the middle of the morning what appeared to be a terrific explosion took place. Actually it was only three primers cutting the pipe in the railway archway, but the noise produced in the relatively confined space was almost too much for the nerves of at least the Coy. Comdr., nearly a mile away at the time.

It is perhaps invidious to single out any particular piece of work for mention, but this one is typical of the spirit of the men who had the work to do. No. 2 Sec. found a way to get their small box-girder up to site without waiting for No. 1 Sec's. bridge. It would mean a long carry, but the pontoon dolly was available. At 1930 hrs., after a long day's work, 16 men, mainly of the recruit parties, walked up to a small box-girder lorry, took a hornbeam section straight on to their shoulders, carried it 200 yards over uneven ground and came back grinning for another one without a rest. The small box-girder was launched as quickly as could be expected under the best conditions: is it any wonder with that spirit behind it?

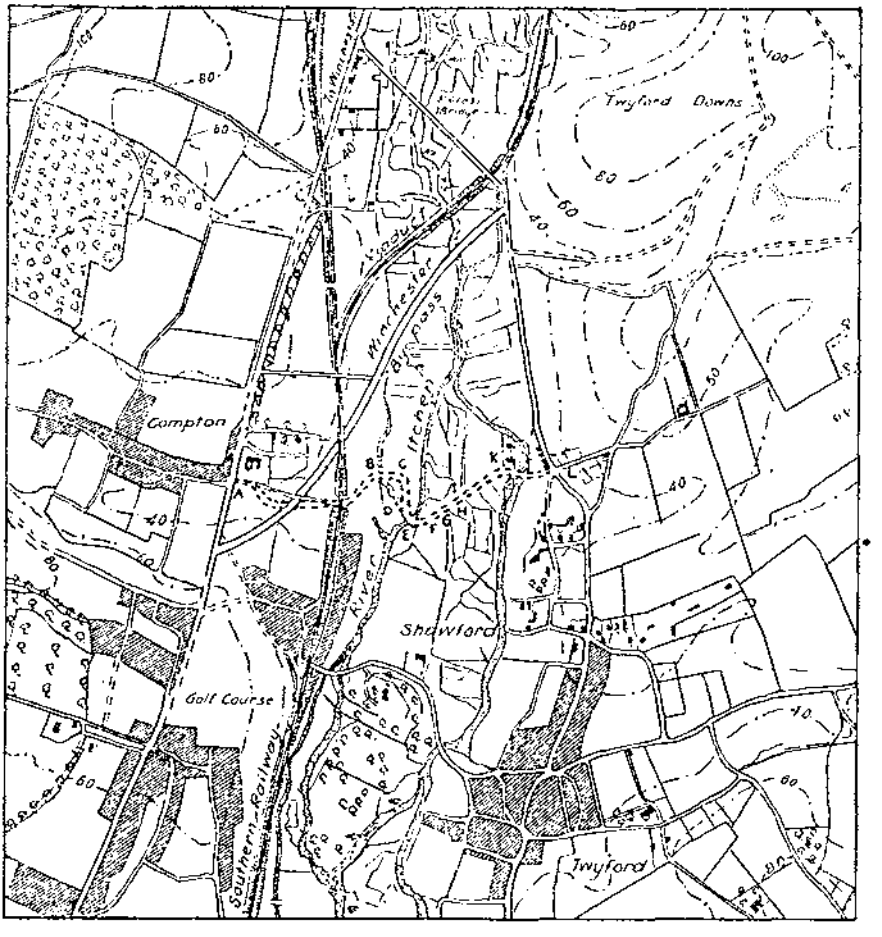
Phase VI.—The Passage over the Route of 4th Gds. Bde. Group.

Of this there is little to say. No vehicle stuck anywhere in the route, at any time. The Brigade was at war strength, as were the 10th Fd. Regt. and A.T. Bty., which accompanied it. Approximately 500 vehicles in all went across.

Two points need mention, A.A. defence and traffic control. The route was in effect a defile 1,500 yards long, in which the speed could not exceed 5 m.p.h. A.A. defence was entrusted to the A.A. pls. of two Inf. Bns. It was agreed that the role would have been better given to the A.T. Regt., who are organized for it specially. They cannot, however, carry out their A.A. and A.T. role at the same time.

Traffic control, with only three passing places and an absolute necessity for sternly restricted speed, was a serious problem. In this case the Fd. Coy. Comdr. asked Brigade to detail a responsible

officer to come with him, study the site, see the ground difficulties, and prepare a plan with him. This worked very well; the officer concerned saw the work from the start and appreciated the necessity



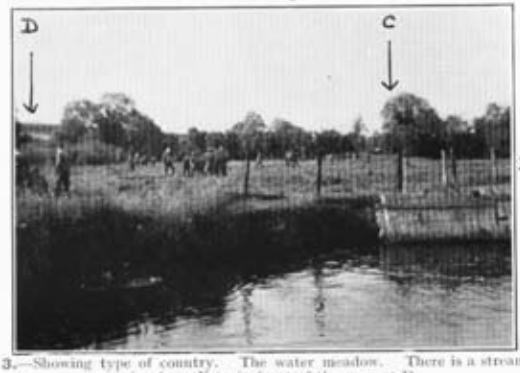
for rigid control. Even then the Fd. Coy. had to help with ten men for traffic duties, to supplement the six military police on duty. And, in a winding route without good visibility, it was necessary for no less than five connected telephones to be put down and staffed

SOUTH

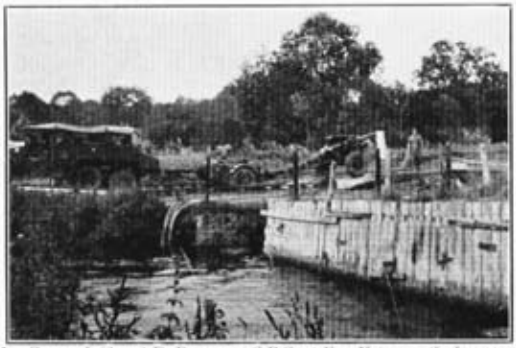
1.—Vertical air photograph of the area. The letters refer to the points marked on the 1/25,000 map. The scale is approx. 9 in. to 1 mile. The route is only shown from the S. Railway onwards.

The new Field Company, RE, at work 1

2.—Completed bridge at B. The first crossing, heavy bridge on R.S.J.'s over total 63 ft.



3.—Showing type of country. The water meadow. There is a stream running from X to in front of the men at D.



4.—Gun on bridge at D. Dragon on S.B.G. at E. Note unorthodox use of S.B.G. launching hoses, as wheel guides!

The new Field Company, RE, at work 2, 3 & 4

by the Bde. signal section in order to allow of control of traffic coming both ways.

During the passage of the Brigade, one section was employed on maintenance the whole time. The weather conditions were mercifully good, and the track stood up reasonably well. It is perhaps interesting that it failed in unexpected places, which was only to be expected.

Phase VII.—Recovery and Reinstatement.

On the evening of September 8th it became obvious that at least one section would be required by the Brigade for work in preparing a defensive position on the 9th. The ominous 1000 A.T. mines came into play. At the same time permission was given to dismantle the crossing after 0630 hrs. on the 9th.

With only two sections to tackle the job, the Coy. Comdr. was safe in assuming that they had a pretty full 10-hour day in front of them. As it happened he was wrong again. The work was virtually finished by noon, 5½ hours from the start. Dismantling is apt to be a dispiriting affair, but it apparently was not in this case. The outstanding achievement here was the dismantling of the small box-girder. The girders were delaunched, across a strip of ground, straight over another stream about 40 ft. wide at the angle at which it was taken, and the operation was carried out by one of the 6th Fd. Park Coy. lorries with a small working party.

Apart from the actual recovery of material, there was a good deal of work done in restoring the site to something like its original condition. On the whole it was left much better than it was originally. The Coy. spent the night on the ground, perhaps unnecessarily, since it was damp, returned to Popham on the 10th, broke up camp there, and except for a rear party were in Aldershot that evening.

Lessons.*

This account would be incomplete without some reference to the lessons which we have learnt as a result of the exercise. We set out on a test of the new Field Coy. R.E., and what have we found?

Some of us thought that in cutting down the working sections from four to three we had lost flexibility and adaptability. In fact, it has been found on this and other exercises that there is more flexibility than before. The working units now number twelve, for each sub-section, carrying as it must some tools in its personnel

* The reorganization of the engineers in formations aims at providing a more fluid and stronger engineer organization in which any small reduction in personnel in divisions is more than counterbalanced by larger and more mobile engineer reserves under higher control.—Editor.

lorry, a winch lorry at that, looks upon itself and acts as a capable self-contained entity. Going a step higher, there are two "tool-carts" in the section, so that two sub-sections can be conveniently handled for a larger job. The section as a whole is one-third as strong again as the old section in working numbers, and it has with it a compressor set. The proof of its powers lies in the results achieved, which are remarkable. Yet there always seemed to be the odd few men with nothing to do for half an hour or so. Certainly they showed no signs of fatigue. Briefly, the lesson is that the new Field Coy. is more flexible, more compact, and more powerful on a job of work than the old. Extra mobility and better equipment more than compensate for the loss of sapper personnel.

The section in its new form is the largest subaltern's command in the British Army. It must have its subaltern to command it, and it would be unfair and unwise to throw it on to a serjeant. Yet, if there is reconnaissance to be done, as there normally is, the Coy. Comdr. cannot be whole-time employed on it. He has lots to do in the way of organization and command. It seems essential that there should be a second subaltern in each section.

We have acquired more mobility and mechanical aids to quick execution of work. These will be wasted unless we study to take advantage of them. It is evident, therefore, that works organization becomes even more important than it was before. Perhaps this item in the training of young officers needs more attention. In war the Coy. Comdr. will not have time to train his subalterns—he must get them ready to take over a complex and quick-moving machine. The same applies in a lesser degree to N.C.O's. What the Field Coy. wants is N.C.O's with a high order of initiative, resource, organizing power, and quick decision, and these qualities must be in every sub-section commander, *i.e.*, in every corporal. It is a very high standard, and one which demands a continuity of training that nowadays is well-nigh impossible to achieve.

The 6-ft. army track all but failed in its object. It could not be kept down at the edges, especially when tracked vehicles used the route. The reason is that there is not enough overlap on each side, above the width of vehicles. Two 4-ft. sections would be far better, allow more latitude for bad driving and make it easier to get round curves.

One final incident and its lessons. The pontoon dolly duly set out from Christchurch in a 15-cwt. truck, with orders to report at Twyford Station by 1030 hrs. Unfortunately there is only one Twyford with a railway station, and that one is close to Reading (!), so dolly went there. Lessons—well, perhaps the reader might think them out for himself.

INITIATIVE.

By Major J. G. O. Whitehead, M.C., R.E.

There are text-books on most subjects of military training, but there is one that is absent—there is no book on training a man's judgment. Yet the exercise of initiative requires not only knowledge (both theoretical and practical) but also good judgment; and although knowledge is trained and can be recognized, the capacity for good judgment is not; in consequence it is often conjectured or doubted on superficial grounds, and risks are guarded against by curtailing initiative. Particularly does this happen in military engineering, which is exposed to the sometimes misleading test of financial analysis, and so an irksomeness arises that ought not to exist. But good judgment is an essential faculty both for war and peace; hence this attempt at an essay on training initiative.

The text is taken from a recent article on "Industrial Management," by Maurice Frydman, in the *Indian and Eastern Engineer;* the clearness and simplicity of the wording provide a delightful insight into human nature. "Initiative (he says) is the power to conceive and execute a plan of action. Display of initiative is one of the greatest joys given to man. It stimulates all his faculties, it gives him self-respect . . . it makes, in however small a degree, a creator out of a creature. The spirit of initiative is one of the most valuable assets of an enterprise and cannot be too assiduously cultivated. Yet to develop initiative in men is one of the most subtle and difficult tasks, and unfortunately there are very few people who have got the necessary qualifications of intense power of initiative, selflessness and genuine goodwill, which are all necessary for the awakening of initiative in others."

The first point to be remarked is the differentiation between conceiving and executing a project. The conception of the work costs little; mistakes may be made and can be corrected; trouble is spent but not money; it is at this point in particular that initiative can be given scope, and can be trained without waste effort, by having the plans developed stage by stage (first the rough outline, then the main detail, and then full detail), each stage being corrected and approved before the next is embarked upon. The essence of the process is clear and comprehensive instructions, framed with the definite object of giving scope for original thought, and judiciously coupled with sufficient guidance to prevent fruitless energy in a mistaken direction. Such is true training, which, like education,

seeks to draw ideas out of a man rather than to shove knowledge in. After the design, in the organization of preparations, the same system holds good—if the proposed organization is set down on paper, and then scrutinized and confirmed or corrected, the junior is given full scope for initiative without the senior being committed to faulty methods. Such is the principle. But it may be held that in practice it is too laborious, neither has the junior time to produce the detailed organization on paper, nor has the senior time to overhaul it. As far as the senior is concerned, that is where perhaps Mr. Frydman's selflessness and genuine goodwill are required; trouble will undoubtedly be entailed, but it is part of the common duty of training. As far as the junior is concerned, most men probably would be glad to undertake the toil if they could foresee the pleasure of being allowed to put their own plans into execution. Again, in the words of the text, it is making a creator out of a creature. And so it is possible to visualize a project gradually progressing, bearing the stamp throughout of original thought by the man on the spot, but never financially or executively out of the control of the man ultimately responsible. The better the man on the spot, the more lightly need the reins be held; or conversely, the more firmly it is found necessary to use the reins, the less is the man proved fitter for promotion—nor, with one proviso, can a man demand a fairer test.

The proviso is that the peculiar fact must be recognized that brain power and imaginative power are in no way synonymous, and that the man with the greatest brains may have the least faculty for visualizing an idea described to him being put into execution. Very many men must have experienced their ideas being dismissed as impractical, and later have had an opportunity of testing them and have found them perfectly practical; the difference has been in the imagination, one man could see the action taking place in his mind's eye, the other could not. The whole history of invention tells the same story. The safeguard for the man without the power of visual imagery is a generous recognition that the other man may be seeing further than himself, and here Mr. Frydman's selflessness is called for—the selflessness that allows an almost humble recognition that one's own opinion may not be infallible. A book, entitled *Clearer Thinking*, has a chapter which indicates some of the fallacies that lead to faulty opinion; it recommends that, when we find ourselves entertaining an opinion about which there is a feeling that even to enquire into it would be absurd, or unnecessary or undesirable, then we may know that its justification is needed. It points out also that other beliefs are held through self-interest, and describes the wide range of concern covered by that term—prestige, popularity, or the goodwill of those whose goodwill is valued; it concludes, "putting it broadly, we should always suspect any of our opinions

when we recognize that our happiness depends, directly or indirectly, upon our continuing to hold them when we might lose anything, material or otherwise, by changing our opinion." Fashion in thinking is an equal danger, leading to fixed ideas; one authority has shown that lack of flexibility in thought depends upon character, not upon age, and that as often as not it starts to set in at the age of twenty-five. Finally, another writer remarks that, if we all feared holding an unwarrantable opinion with the warmth that we fear using the wrong implement at the dinner-table, then the world would be more governed by sense. The long and short of the advice given is to cultivate an open mind, and a readiness to subject any proposal to an *ab initio* consideration, unprejudiced by predilection, personal concern, or current popular opinion. A reasoned and generous open-mindedness towards new ideas is a second necessity for developing initiative in others.

The idea of judgment being swayed by self-interest raises a very interesting study of military history. Probably no man would be more emphatic than the person taking the decision himself, in denying that self-interest had ever entered his thoughts; and yet when history is read, it is patent time and again that influences of that nature have lain at the root of military mistakes. No such obvious motive as personal glory or gain has necessarily operated, but some far less easily diagnosed idea related to self, as for instance happened in Banks' decision to stand at Strassburg (American Civil War); this was done ostensibly in order to develop the force of the enemy, but actually because he was afraid of being thought afraid. Another example is in Ney's failure to develop all his force at Quatre Bras; he fought with the utmost courage with the troops in hand, yet it was in his power to bring up more, and he did not do so; history has attributed the omission to wilfulness and perverseness on his part. The more the subject is studied, the more subtle do the ways appear in which personal influences make themselves felt; the only method by which a man's judgment can be kept clear seems to be by a habitual disregard of his own personal feelings or prejudices. An outstanding example of this is in Wellington; his disregard of self was almost ascetic, and his judgment was phenomenally clear, right up to the end of his days; his contemporaries expressed it as "a victory of mind over matter." There is no positive evidence on which to connect selflessness and judgment in his instance, but there seems no other explanation—he certainly did not act upon principle, but gave every problem a momentary reasoned review—and the remarkable soundness in his decisions seems to have been the outcome of a disinterestedly schooled habit of thinking. Judgment in everyday affairs follows similar lines; the counterpart of Banks afraid of being thought afraid can be pictured as the man afraid of being thought harebrained, or reactionary, or any other term of

popular derision at the time. Fostering initiative needs moral courage, and the use of it needs self-control; part of its training, accordingly, requires a disciplined selflessness, and it is scarcely necessary to add that this applies to unofficial affairs as well as to official.

Another part of the training is the encouragement of original thought; and the greater the scope offered, the better the training. Here it is that Mr. Frydman's genuine goodwill is called for; the process may have to be an extremely unselfish one, entailing the interest and credit going to someone else, and, it may be, the risk of carrying the blame in the event of failure; the latter, though, need not exist if the preliminary measures be well conducted. The self-denial required to forfeit the interest and credit is more difficult to recognize; "the good of the service" may seem to advocate close control, and yet what to the interested person may appear as "the service," an impartial observer may detect as the person himself—"*L'état c'est moi*" has led many a dictator astray, and in a small way the same self-deception is liable to happen to anyone in authority. The safeguard perhaps is a generous aim to give opportunities to others, and to judge men generously.

To make a man capable of acting on his own, therefore, needs giving him, in addition to knowledge, the power of original thought to apply that knowledge to circumstances. It is producing the habit of creative thinking in contrast to an accumulated store of facts. As to whether it is worth while pursuing the training with this aim can be gauged from the heading of the article from which the text of this essay was taken, "Industrial Management." If industry can advocate it, then it will be financially worth doing; even more so in the Army, preparation for war-time efficiency requires a margin which cannot be calculated entirely in terms of finance. Perhaps in this commercial age the mode of thought has arisen for apparent material returns to be given greater heed than real efficiency. Not that it is suggested finance could or should be disregarded; it is surely a very material factor, but a factor only, and not the object. Nor will finance be the only difficulty; customs, changes in personnel and policy, all may figure. But where there's a will there is always a way, and the essential element needed for providing training in initiative is the frame of mind in the trainer that sees in every work scope for giving it, and sees it his business to organize the work with that end in view, controlling the exercise of it carefully, giving freedom where freedom will be well used, and shepherding it where it is wandering from the track. It needs also the frame of mind that will enjoy seeing others earn credit in the opportunities he has given, and which has the hardihood to face uncertainty, and can say like Edward, when his own success was in the balance at Crécy—"Let the boy win his spurs."

MODERN METHODS OF CONCRETE CONSTRUCTION IN QUETTA.

By CAPTAIN H. H. C. WITHERS, R.E., *and* MR. E. G. RUSSEL, A.M.INST.C.E.

SOON after the disastrous earthquake at Quetta in May, 1935, the Government of India decided to rebuild the town and Cantonments on the original site on earthquake-proof lines. Specifications were accordingly drawn up; tenders were invited in the spring of 1936 and new construction work was started in Cantonments in the summer of the same year.

The work about to be described forms part of one of the first three contracts for Quetta Reconstruction and consists of lines for three Indian infantry battalions, of a total value of Rs. 27 lakhs (approximately £200,000). It is being carried out by Messrs. Gammon, Ltd. About 500,000 cubic feet of concrete have now been poured, and as the methods of construction adopted are rather unusual, they may prove to be of some interest to those engaged in reinforced-concrete building work presenting considerable repetition.

The buildings consist of a number of types, with not very dissimilar features and with a considerable amount of repetition work in each type. All the buildings are of reinforced-concrete single-storey construction, designed to withstand an earthquake force produced by an acceleration of g/8. The question of structural design, however, does not enter into the scope of this paper.

As a typical example of the type of construction Fig. (i) shows an Indian officer's quarter, of which there are sixty to be built in this contract.

The contractors were faced with two main problems:—

(1) The speed of construction necessary due to the short working season; the Quetta winter is so severe that concrete can only be poured without special and expensive precautions from April to October, and all other work is seriously curtailed.

(2) The possibility of a shortage of labour, owing to the very large amount of work involved in the first three contracts given, and the probability of still further contracts being awarded in the near future.

In view of this it was decided to use mechanical methods of con-

struction as far as possible. To this end a central 22 cubic feet weigh-batching plant was erected, from which the concrete is conveyed to the job in skips on 30-cwt. lorries. Steel shuttering is used throughout and to avoid the waste of time involved in "lifts", it was decided to pour the buildings their full height in one operation.

It will be seen from Fig. (i) that the walls are only 4 in. thick and are 13 ft. high with central reinforcement. These walls are typical of the general design, the only departure being the barrack walls, which are 5 in. thick with reinforcement in each face.

After carefully considering these factors, the conclusion was reached that normal methods of consolidation were out of the question and that the concrete would have to be consolidated by vibrating the shuttering. This method would have the advantage of cutting out the "punning" or "tamping" gangs.

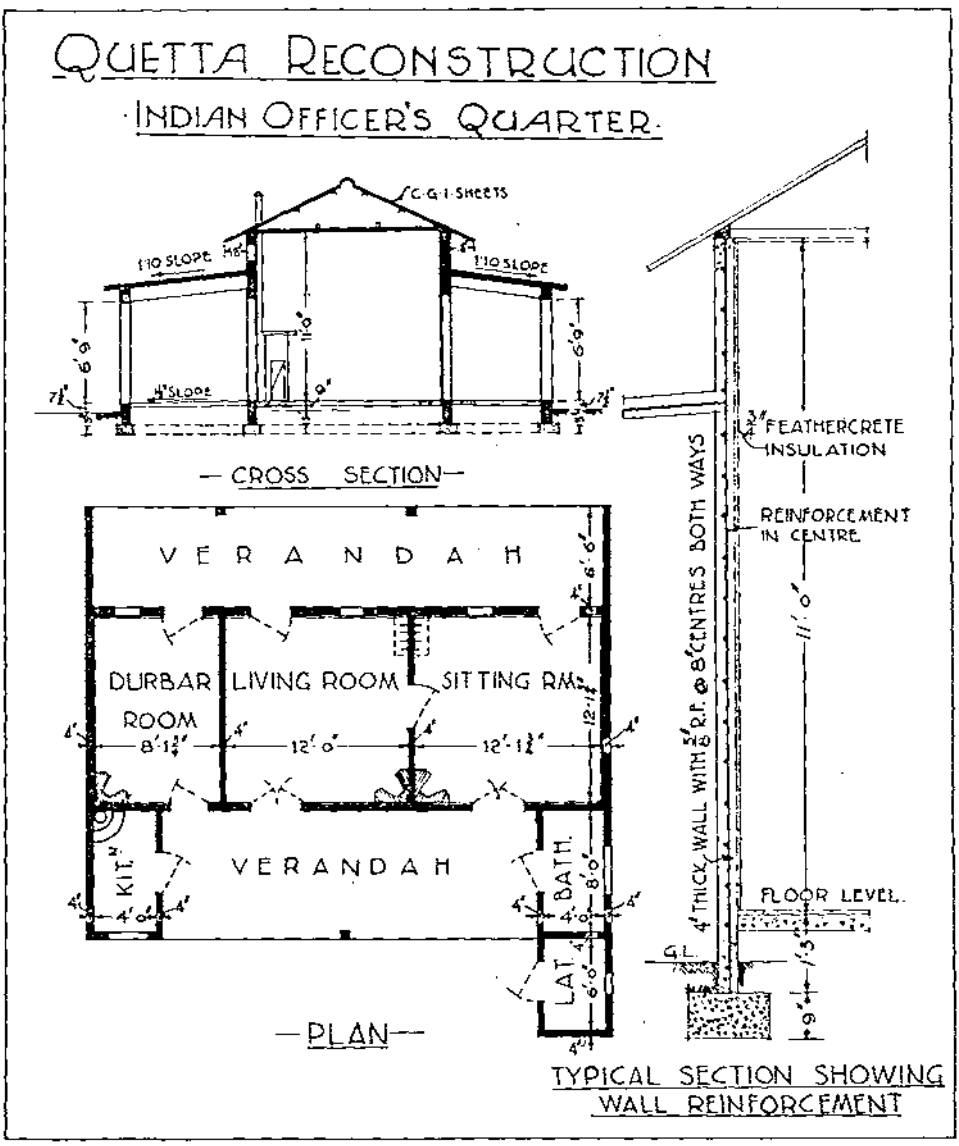
Design of the Shuttering.

Under these circumstances it was realised that very high pressures would be developed by the concrete in the shuttering as, due to vibration, the concrete at the bottom would be kept in a plastic state and would continue to exert a pressure, almost equal to that of a fluid of equivalent weight and head, when the concrete in the top layers was being poured. In designing the shuttering, allowance was made for this by taking the pressure for the full height as equivalent to that of a material of weight 150 lb./cubic foot with an angle of repose of 10 degrees, Rankines' formula being suitably modified to allow for the narrowness of the walls. In addition, as the shuttering itself was to be vibrated, special attention had to be paid to the rigidity required to transmit the vibrations properly and to the strength required to withstand the additional stresses produced.

Description and Erection.

The shuttering for the building shown in Fig. (i) consists of rigidly-braced steel corner-pieces connected by steel plates about 13 ft. by 8 ft. stiffened with angles, which bolt together to form an interior box of the full height of 13 ft. without any interior cross-bracing. To this the steel doors, windows and ventilators are bolted and the heat-insulating material, consisting of pre-cast slabs of "Feathercrete," $1\frac{3}{4}$ in. thick × 2 ft. × 4 ft., is fixed by building it against the shuttering like brickwork with cement mortar joints and securing it with binding wire. When the inner box is completed the reinforcement, made up into panels at a central steel yard, is placed in position and the outer shuttering, which is similar to the inner, is then erected and bolted to it. The steel is kept central in the walls by thin concrete reels, 4 in. in diameter, threaded on to the bars when being made up

FIGURE 1.


QUETTA RECONSTRUCTION
INDIAN OFFICER'S QUARTER
C.G.I. SHEETS
1:10 SLOPE
1:10 SLOPE
4" SLOPE
— CROSS SECTION —
VERANDAH
DURBAR ROOM
LIVING ROOM
SITTING RM.
VERANDAH
KIT.
BATH.
LAT.
— PLAN —
3/4" FEATHERCRETE INSULATION
REINFORCEMENT IN CENTRE
4" THICK WALL WITH 5/8" R.R. @ 8" CENTRES BOTH WAYS
FLOOR LEVEL
G.L.
TYPICAL SECTION SHOWING WALL REINFORCEMENT

into panels, while the outer shuttering is held in place by the end-plates and by numerous through-bolts threaded through 4 in. × 2 in. × 2 in. distance pieces. See photographs C and D.

METHOD OF POURING AND CONSOLIDATING.

The original plan was to carry the concrete from the batching plant to the building in skips on 30-cwt. lorries, to hoist the skips over the building by a crane and to empty them straight into the walls. The vibrators were to be attached directly to the walls by means of jaw clamps. It was considered that one crane and six vibrators would be sufficient for a building such as that shown in Fig. (i), and that the best concrete mix would be of the coarse, dry type usually advocated by most authorities for vibrated work.

The first building was poured according to these ideas, but when the shuttering was removed, the results were such as to cause grave doubts as to the possibility of success ever being attained by these methods. However, the arrangements had all been completed and the plant had nearly all arrived at site, so that the engineers were committed. More vibrators were ordered, the idea of pouring direct into the walls was abandoned, the speed of pouring was increased by the use of two cranes, the organisation vastly improved, and the mix radically altered, with the result that success was gradually attained.

It was found that, in pouring, the two most important principles are :—

(1) Speed. To avoid segregation at the junctions of layers, one layer must be placed before the layer below has lost its workability. It appears from reports of the Building Research Station that concrete may be vibrated and left for long periods (up to 17 hours) and still be worked by vibration without any very harmful effects. This has not been found to be the case under the conditions prevailing in Quetta. Wherever layers of concrete are left for periods of much over an hour before the next layer is placed, the two layers do not run together, definite lines of separation with a thin layer of fines on top of the lower batch of concrete, usually accompanied by honeycombing in the upper batch, are the almost invariable result, which no amount of extra vibrating appears to overcome.

(2) The concrete must be poured in such a way as to maintain as far as possible a constant level around the building.

To ensure that these principles are maintained, careful organization in pouring is necessary.

Originally, the skips for the concrete were designed with 4-in. openings to allow the concrete to be poured direct into the walls, but

this was found to be impracticable. The best results were obtained when a small gang was employed to shovel the concrete from trays into the walls. While increasing the number of men employed, this method has the advantage that the concrete is turned over before going into the walls, thus correcting any segregation which may take place in the journey from the batching plant.

The method finally evolved is to place two trays on platforms in each room (see Fig. (i)) , into which two cranes, working one from each end of the building, empty the skips in a pre-arranged order of rotation ; the concrete is then shovelled from the trays into the walls under careful supervision to ensure that the levels are correctly maintained.

The organization of the vibration is also of the first importance.

Preliminary trials with various types of vibrators may be needed, as the size, strength and rigidity of the shuttering may be more suited to one make than to another. The first six vibrators tried on this shuttering never gave good results ; the second type, after overcoming certain difficulties, have given excellent service.

Each vibrator was originally clamped by means of jaws direct to the angles of the shuttering, but the shuttering was not sufficiently rigid and allowed the whole vibrator to move in forced oscillations of low periodicity, with the result that it frequently failed to attain full speed. Subsequently, channel clamps were designed to which " U " brackets for carrying the vibrators were welded, which could be bolted to the shuttering wherever desired. These gave a more rigid connection and overcame this difficulty. (See photograph D.)

At least 25 vibrators are required for a building of the type illustrated. They are usually spaced about 4 ft. apart, but each building has to be considered on its merits with special reference to the position of doors and windows. The vibrators must be moved up and around the building as the concrete rises ; at the beginning they are placed about 2 ft. above the bottom of the shuttering and are kept in that position until the concrete has reached a height of about 4 ft. ; they are then raised to a position 6 ft. up the shuttering where they remain until the concrete reaches a height of about 8 ft., and so on until the pouring is completed. Where there are windows a vibrator is required on each side, to ensure that the concrete flows under it and completely fills the space beneath the window. Holes are drilled in the shuttering under the windows and doors, through which the concrete exudes when the space has been filled. The hole is then plugged. These holes also allow the escape of air and prevent air locks, which at first caused difficulties in completely filling under windows.

It appears that no hard and fast rule can be laid down for the time of vibration. The vibrator is switched on as the concrete is about to be shovelled in to the shuttering and is kept running until the concrete

has flowed to the desired level and until the appearance of a thin layer of mortar on the surface. This usually takes between 1 and 2 minutes after the last shovelful has been placed in position. Excessive vibration has a tendency to bring all the fines to the top, thus causing honeycomb patches lower down. To help in finding any piling up of the concrete at the bottom of the forms, where it is difficult to see and to assist in its rapid dispersal, two men in each concreting gang are provided with long rods to "pun" down in the walls, since if such piling up is allowed to remain and the next layer placed on top of it, honeycombing and holes due to the concrete not flowing properly are likely to occur.

Finally, there is the question of the mix. This is a nominal 1 : 2 : 4 mix, but in view of the greater strength and consolidation expected with the use of vibrators, a special clause in the contract allows the contractor to use up to 10 per cent. more aggregate in the mix.

The materials available locally consist of :—

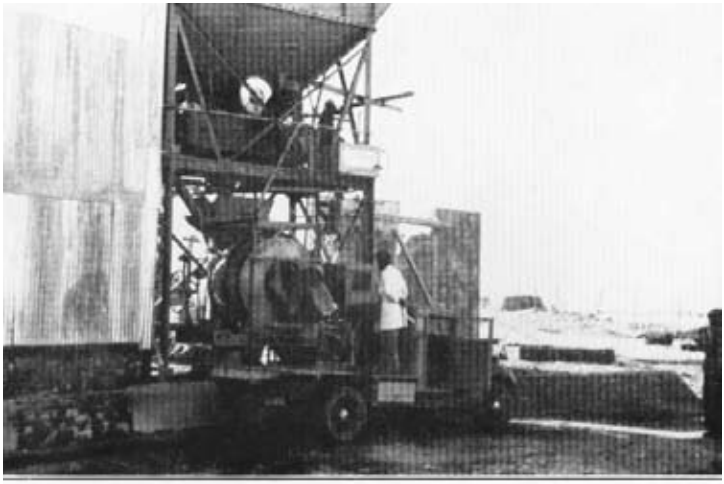
(*a*) A mixed gravel giving a good, hard, but very dirty shingle, and a coarse sand lacking completely any material finer than a No. 28 B.S. sieve. This is obtainable in large quantities within five miles.

(*b*) A very fine river-bed sand which is dirty and contains small lumps of clay which have to be removed by screening. This sand has no material coarser than a No. 14 B.S. sieve. It therefore can only be used in small quantities to provide the fines lacking in the gravel. This material can be obtained from about 15 miles outside Quetta.

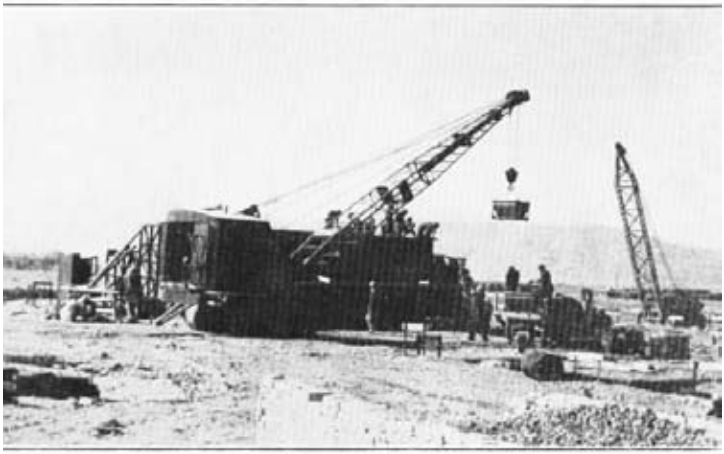
(*c*) A rather soft limestone from quarries in the local hills about 5 miles away. On all the various types of crushers which the different contractors have used, this limestone always gives an excess of material between the $\frac{3}{8}$ in. and $\frac{3}{16}$ in. sieves and also a very large amount of dust.

The Military Engineer Services established a concrete-testing laboratory at Quetta and carried out a large number of preliminary tests to find the most suitable gradings. During the course of these tests it was found that, even with the most careful washing, the shingle still appeared to have a film of clay on the stones; it was therefore decided that crushed aggregate must be used in conjunction with the shingle. It was also discovered that no suitable grading could be obtained without using a small proportion of the river-bed sand, which had to be washed and screened.

The contractors installed a crushing plant close to their batching plant, consisting of two "Lightning" crushers each with a set of vibrating screens. The original sizes of screens installed were $\frac{3}{4}$ in., $\frac{3}{16}$ in. and a No. 70 B.S. sieve. This combination was found to give most unsatisfactory gradings. After various trials the screens adopted



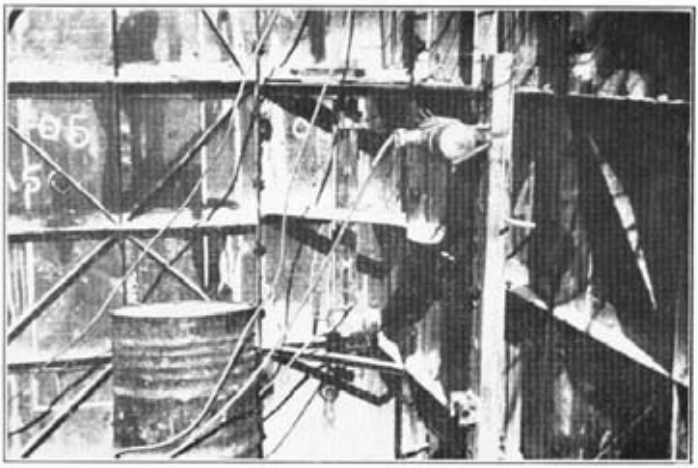
A.—Batch mixer, showing skips being filled.



B.—Concreting in progress.

Modern methods of concrete construction in Quetta A & B

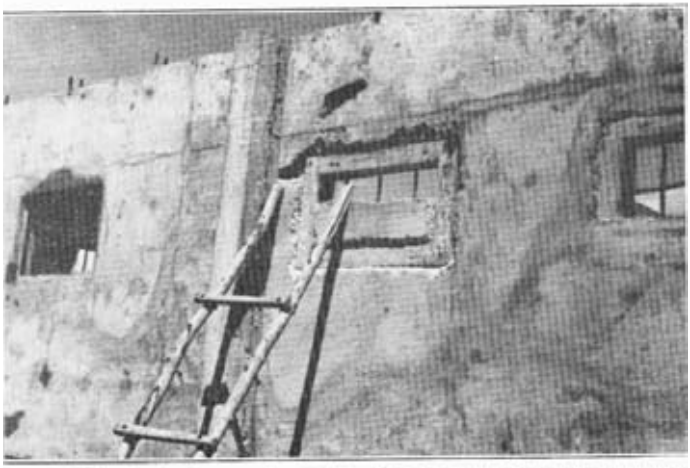
C.—Partially erected shuttering. This shows clearly :—
(a) The stiffness of the shuttering.
(b) The method of framing in the windows.
(c) The reinforcement.
(d) The heat insulating material built up against the inner shuttering.



D.—Vibrator clamps.

Modern methods of concrete construction in Quetta C & D

E.—Vibrator fixed to a "needle" for vibrating roofs or small beams.



F.—A leak in the framing round a window. Result:—A partly solid window and a bad hole above it.

Modern methods of concrete construction in Quetta E & F

G.—Honeycombing, due to "piling up" of the concrete in the forms.

H.—Patching. Bad honeycomb places, as in G, cut out and patched.

Modern methods of concrete construction in Quetta G & H

were 1 in., $\frac{1}{4}$ in., $\frac{3}{16}$ in. and a No. 100 B.S. sieve, enabling the excess of small stones and dust to be eliminated. With vibrating screens the life of a No. 100 sieve was found to be very short, so that later a solid plate was substituted and a suction dust eliminator installed. This combination gives fairly satisfactory results, with the additional advantage that the quantity of dust in the atmosphere near the plant is materially reduced.

Even with all this attention to screening the crushed rock, and in spite of numerous efforts to eliminate it, it has been found impossible to obtain a suitable grading without the addition of a proportion of the river-bed sand with the attendant danger from the small lumps of clay.

Fig. (2) gives limiting grading curves A and B for $\frac{3}{4}$ in. mixes containing crushed aggregate and S and B for mixes containing natural aggregate only, worked out by the authors at Quetta. They were arrived at by a process of elimination from several hundred test results of concrete poured by the various contractors in Quetta, and have been found to be very useful as guides for keeping control over the grading. Curve C gives what is considered to be an ideal grading, giving a good workable mix with a high strength. It is of interest to note that the curves lie very close to those published by Dr. Glanville in his paper prepared for the annual meeting of the Institution of Municipal and County Engineers in June, 1937.

As previously, stated it has also been found that the dry mixes usually advocated for vibrated concrete, and tried out in the early stages, produced most unsatisfactory results, giving bad honeycombing and segregation troubles.

The strength specified in the contract is 2,400 lb. per sq. in. on a 6-in. cube at 28 days. The ideal mix for the type of work described in this paper appears to be a well-graded mix with a slump of $3\frac{1}{2}$ in. (+ or − $\frac{1}{2}$ in. tolerance). This can readily be obtained with a water-cement ratio of 0·75 (by weight). With this W/C ratio the specified strength is normally attained in seven days, but it was found that if the W/C ratio drops to a value of 0·8 or lower, the cube strengths are apt to be lower than the specified minimum. The presence of excess dust in the crushed aggregate, or of dirt in the shingle or fine sand, are ever-present dangers liable to upset the mix and have constantly to be guarded against, so that it has been found necessary to keep a close and continuous check on the mix. This is done through the medium of the M.E.S. laboratory.

Samples of the materials are taken four times daily by the M.E.S. from the contractors' bins for the usual standard tests. The sieve analyses are communicated immediately to the contractor for working out his gradings, giving a continuous check and allowing adjustments to be made as necessary during the progress of the work. Similarly, a very close check is kept on the quantity of water in the

mix. All materials are weighed into the mixer in the direct-reading hopper and the water measured in from a graduated tank. Tests for water in the sand are taken at frequent intervals on a "Toledo" balance. This machine gives direct readings for the quantity of water in the sand and by its means the batching plant operator can find the total quantity of water in the sand in a couple of minutes. It is probable that it is the first machine of its kind in India. It certainly simplifies checking the quantity of water in the mix and allows a quick and accurate control to be kept. Any variations in the slump for a given quantity of water, or any sudden rise in the water content required for the given slump, indicates that all is not well with the aggregates and adjustments can immediately be made as required.

Test cubes are also taken from the work two or three times daily. One cube from each batch is always crushed at seven days in order to give the contractor early information on what to expect at 28 days.

The question of the extra concrete used in a given volume due to the better consolidation to be expected by vibration is important, especially from the contractor's point of view. A great deal depends on the grading, but it would appear from measurements taken on this contract, and on similar work on other big contracts in Quetta, where normal methods of consolidation by punning are used in 3 ft. lifts, that there is very little difference in the quantities of materials used.

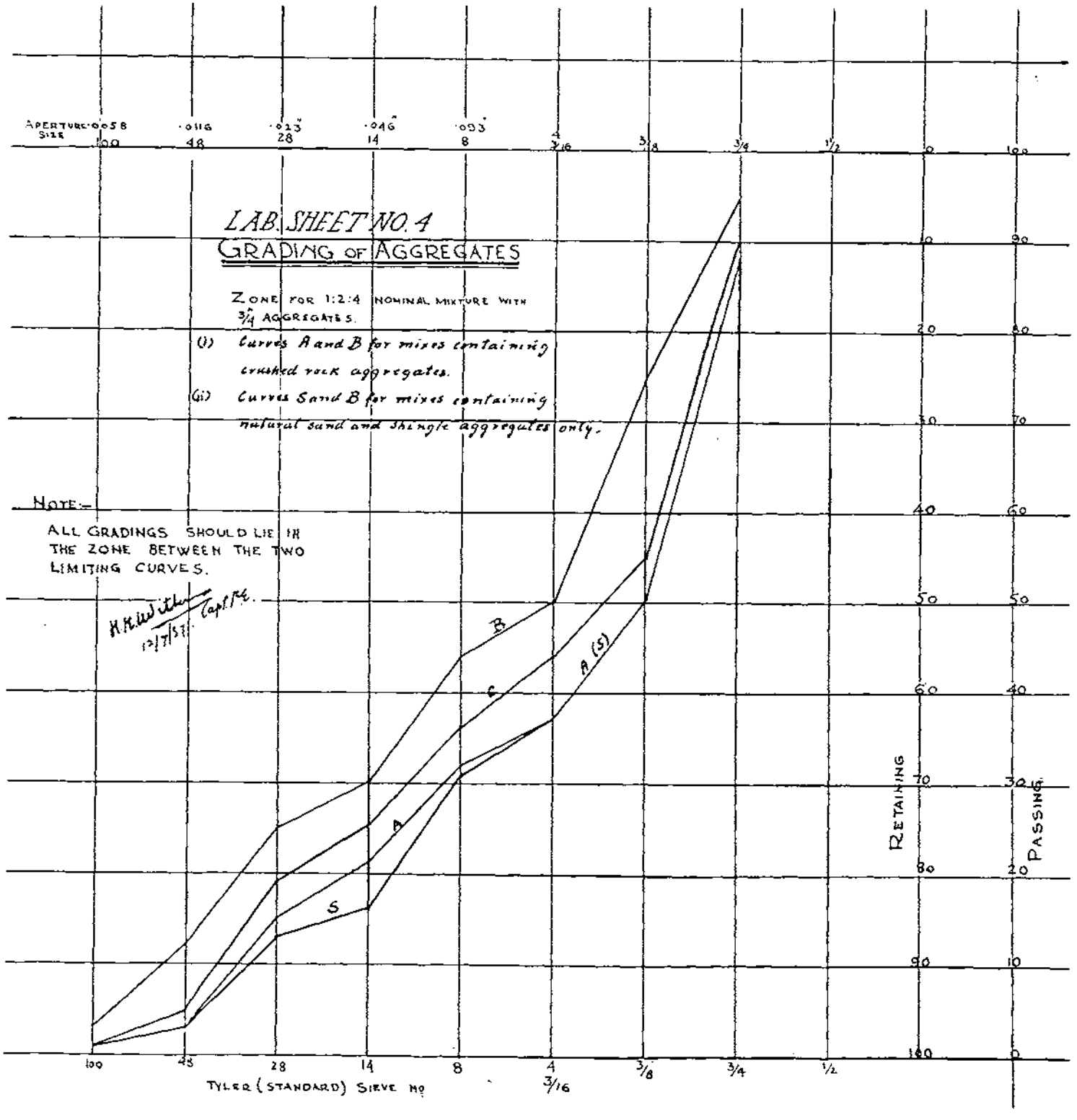
CONCLUSIONS.

(1) The method of concreting adopted, although contrary to accepted practice of not pouring from a height, has proved successful. There were, as was only to be expected, many difficulties, but these were gradually eliminated and the desired result of high-speed construction using a minimum of labour has been attained. For example, the shell of the Indian Officers' Quarter, shown in Fig. (i), with a concrete wall area of 1,600 sq. ft., is poured regularly in $3\frac{1}{2}$ hours, while the complete cycle for the erection of the shuttering, reinforcement, heat-insulation, etc., pouring the concrete and removal of shuttering, is five days.

(2) Shuttering for this type of construction has to be specially designed to withstand the high pressures produced by a 12-ft. head of concrete kept plastic by vibrating and in which the top layer may be poured only three hours after the bottom layer. Rigidity for the vibrator fixings and for transmitting the vibrations must also be considered.

(3) In pouring from heights greatly in excess of those normally permitted and into very thin reinforced sections, the dry coarse mixes, containing only 35 per cent. of material passing a $\frac{3}{16}$ in. mesh sieve with a W/C ratio in the neighbourhood of 0·4 by weight,

FIG. 2.


APERTURE SIZE
·0058
·0116
·023"
·046"
·093"
100
48
28
14
8
4
3/16
3/8
3/4
1/2
0
100
LAB. SHEET NO. 4
GRADING OF AGGREGATES
ZONE FOR 1:2:4 NOMINAL MIXTURE WITH 3/4 AGGREGATES.
(i) Curves A and B for mixes containing crushed rock aggregates.
(ii) Curves S and B for mixes containing natural sand and shingle aggregates only.
NOTE:-
ALL GRADINGS SHOULD LIE IN THE ZONE BETWEEN THE TWO LIMITING CURVES.
H. Kellow Capt R.E.
12/7/51
B
C
A (S)
A
S
10
90
20
80
30
70
40
60
50
50
60
40
70
30
80
20
90
10
100
0
RETAINING
PASSING
100
48
28
14
8
4
3/16
3/8
3/4
1/2
TYLER (STANDARD) SIEVE No

recommended in a recent paper read before the Institution of Civil Engineers, appear to be entirely unsuitable. A mix with about 45 per cent. of material passing the $\frac{3}{16}$ in. sieve with a W/C ratio of about 0·75, giving a slump of about $3\frac{1}{2}$ in., gives the best results, with an average strength, in over 2,500 cubes crushed, of 3,295 lb. per sq. in. at 28 days.

(4) When a mix of this type is consolidated by vibration it appears that the extra material used, compared to consolidation by punning, is very little—between 1 and 3 per cent. This is also borne out by a comparison of the weights of cubes made on a vibrating table with that of those consolidated in the standard manner. The higher figures, up to 10 per cent., mentioned by various writers may be due to the use of much less workable mixes, which cannot be so well consolidated by hand.

(5) It would be interesting to obtain some information on the acceleration and period of the vibrations transmitted to the concrete. The vibrators give 6,000 shocks per second, but the vibrations transmitted to the concrete are likely to be very complicated and to vary within very wide limits. This will particularly be the case between the time when the shuttering is practically empty and when it is almost full. Unfortunately, neither the time nor the apparatus is available at Quetta to study these problems.

D.C.R.E. FINANCE.

By MAJOR E. BADER, R.E.

ACKNOWLEDGEMENTS are due to the previous writers on this subject,* who have dealt with the control of a single Part I Service. This article is an attempt to expand the theme by a description of a working system of financial control for a D.C.R.E.'s area with a good deal of work in progress. In the area in question, we had five major Part I Services as well as numerous smaller Part I and Part II Items, plus the maintenance of a number of old barracks. Finance was centralized in the D.C.R.E.'s office. An indication of the work in hand at one time, covered by the system to be described, is given in Fig. 8.

CONTROL PROBLEMS.

These are :—

A. Control of Funds.—How much money do I want this year, next year and total, for each subhead and item? Have I included all possible charges in my estimate. Does the answer cover the latest changes in policy or design?

B. Control of Progress.—In case of each *contract*, how much work has been done each month, what is the value of stores on site, how much can I pay on account, is progress up to schedule, where is the cause of delay, when shall I finish each building or unit, and the whole job? Most important, how can I get the answers to these questions without throwing extra labour onto my clerks of works?

Here the issues lie between the D.C.R.E. and contractors and cut right across the system of estimates and financial forecasts by subheads and items.

It is of first importance to keep A. entirely separate from B., otherwise a muddle will result on account of the following complications which must be faced :

(*a*) Fluctuation of local currency. Affects A. more than B., and complicates carry-overs.

(*b*) One allotment may cover several contracts in one or more G.E.'s areas, as the example in Fig. 3 discussed later.

(*c*) Conversely, one contract may include several services or (worse), parts of services.

(*d*) Supervision, direct labour, W.D. stores and miscellaneous charges apply to votes and subheads but the incidence of the work involved is in respect of contracts.

* Lieut.-Col. G. MacLeod Ross, M.C., R.E., *The R.E. Journal*, June, 1933. Major W. G. R. Nutt, M.C., R.E., *The R.E. Journal*, March, 1937.

(*e*) Deviations, plus or *minus*, on contracts. The former are usual, the trap being the " per cent. limit " ; the latter occasional, usually to conserve funds, for a change of policy.

(*f*) The habits of the local contractor, in this case Chinese. A good fellow, but dilatory if the supervision proves better than he expected when he tendered, and unduly optimistic regarding time and progress.

Basis of System.

As the G.E's have no allotments or finance clerks, the principle used is that the G.E. estimates and progresses the work by contracts or " jobs " and the D.C.R.E., after checking this information, uses it for monthly payments on account and for conversion into terms of subheads and items, fitting it into the jigsaw of the W.D. accounting system.

Estimating.

The D.C.R.E. is not usually concerned with preparation of preliminary estimates for larger services—A.F.M. 1426 system. His estimates are of two kinds, viz.: preliminary estimates for smaller services such as those subject to local approval, and accurate estimates and forecasts of expenditure by years of all services after the contracts are let and in his hands for execution.

All but very simple and minor estimates are dealt with as follows. The first step is to rope in the G.E. concerned by calling for an " Estimate Form I," see Fig. 1, for the job or contract. It will be noticed that what the G.E. produces is the estimated cost—contract, supervision, labour, stores, transport and other charges—for a specific contract, irrespective of the items concerned. For a big service, the G.E. has to list and estimate his stores, also work out and get approval of his E. and M. scheme before the items other than contract cost can be included, consequently a preliminary guess based on previous experience may sometimes be necessary.

The last estimated item on the Form I, " Contingencies," is a reserved item decided by the D.C.R.E. after discussion with the G.E., and is usually much more than the figure for " unforeseen work " included in the contract. A good guess at this item is most important and should form an answer to the following sort of question :—

Do the drawings—often prepared hurriedly without time for accurate survey—really cover the job, *e.g.*, drainage, turfing, tidying up? Does this C.W. or that mechanist tend to under-estimate his stores? Will higher authority stick on a few extra works and force me to the deviation limit? Is the virgin hillside solid granite or just cheesy yellow earth underneath?—and similar flights of fancy. It is no use just " guessing big "—the C.R.E. can put difficult questions as to why you are asking for unauthorized funds, and in any case,

you land yourself with an awkward saving at the end of the job or the financial year. On the other hand, an adequate figure will save endless correspondence, appeals for funds, alterations to forecasts and so on. Care is needed to include only those probabilities which must or will be authorized in due course, for example, allow that the areas shown turfed on the drawing will in fact be much larger on the ground, but do not include for a couple of extra tennis courts above synopsis because you have a friend in the unit.

This description shows that a "Form I" estimate cannot be prepared until the job has been studied in some detail. It is surprising how often this results in snags coming to light and in general clarification, reducing trouble later on. After the work is in full swing, revised estimates are prepared from time to time, say at intervals of three months for a big contract, to bring the figure up to date as regards scope of the work, costs of stores and other charges. A revised form, showing deviations to date and the original "Contingencies" correspondingly reduced, is shown at Fig. 2.

When the G.E.'s estimate for a job or contract has been discussed and agreed on, the D.C.R.E. boils it down with any others applicable to the particular item concerned, into a "Combined" or "Link" Estimate, Fig. 3. Where one contract covers part of several items, the amount is split by the D.C.R.E. and the allocation of the various parts noted on the back of the Form I for the contract. These amounts are then carried to the combined estimate for the item.

Estimate Book.

All estimate forms are kept permanently on the D.C.R.E.'s desk in a loose leaf book under the two subdivisions "Estimates" and "Combined Estimates." The forms in each subdivision are indexed in chronological order and any revised estimate is inserted next to its predecessor for the job or item in question and given a suffix letter, see Figs. 1 and 2. Consequently one can find out at once whether an estimate exists, when it was produced and whether it has been revised. Work, often very considerable, done in preparing estimates is not lost on scraps of paper or buried in the files, but is immediately accessible to the D.C.R.E. and finance clerk.

Monthly Forecasts of Expenditure.

These are required by the C.R.E. from July onwards. The requirements are, first, an estimate of the whole cost of each item which covers everything and does not have to be revised upwards as the work proceeds, and, second, an estimate of the current year's requirements which is as near the mark as possible without exceeding it and thereby causing a lapse of funds at the end of the year.

Forecasts are prepared as follows. D.C.R.E., G.E.'s and F.C.

assemble and discuss the estimates and progress records to be described later. D.C.R.E. records on the back of each form, see Figs. 1 and 4, notes of any considerations affecting probable progress to the end of the year. These include: adjustments foreseen in the scope of the contracts due to changes in policy, knowledge of contractors' financial status—a big item where many of the lesser firms struggle along on excessive overdrafts—allowances for the usual weather and holiday delays, and the following traps: If a contract is due to finish about the end of September or of March, a few days one way or the other will decide whether the final payment, or payment to " one-third reserve " respectively, is made in the current or the next financial year. In the case of large contracts, sums running into thousands of pounds are involved.

Having collected the data, a forecast of expenditure by years is made, noted on the back of the " Form I " and recorded by F.C. on the C.R.E.'s monthly progress record, A.F.K. 2425.

New information may come to hand any time during the month, *e.g.*, a 'phone message to the effect that a new building is to be added as a deviation to a current contract. This is noted forthwith on the back of the estimate for the item and comes to notice at the next review.

Check Estimates.

This system serves until January, but from then onwards it is advisable, at any rate for the larger services, to cross-check as follows: Study the expenditure to date in the ledger, add a guess for further progress on contract during the year; get from O i/c R.E. Stores the Indents (A.B.43) outstanding and his latest estimate as to what will arrive in time to be billed (as the time lag from demand to delivery is often six to eight months, this is difficult), pick up from the Order Book any T.C. orders chargeable to the service and often otherwise overlooked; and estimate the probable transport and imprest charges to come. The answer should be fairly near the mark.

Progress System.

As stated previously, the progressing system summarizes the relations between the D.C.R.E. and contractors irrespective of W.D. Subheads and Items, and forms the basis of control of work under each contract. Half the battle is to find out where the job stands without exhausting your somewhat exiguous staff in the process. The other half is to have the contractors know that you know. If they understand and trust the system, there are no grounds for argument regarding payments on account, work being behind schedule, lack of organization or other similar subjects.

The principle is that the G.E. in charge of the job records the progress monthly in a standard manner described on page 44, and this

record is used by the D.C.R.E. for payments on account, forecasts of completion and all dealings with contractors.

CHOICE OF SYSTEM.

There is obviously no time for detailed measurement and abstract every month. On the other hand, we have no genius on tap, capable of casting an experienced eye over a dozen or so scattered buildings, etc., in all stages of construction and announcing " by eye " that the job is " 60 per cent. complete." Consequently some happy mean is required, as near as possible to measurement by eye consistent with reasonable accuracy. This involves subdividing the contract into suitable units and estimating the progress of each. The first essential is to subdivide in a manner that makes the task of the C.W. concerned in measuring progress as simple and easy as possible.

Local W.D. construction is chiefly in reinforced concrete so that 70 per cent. or more of a structure is represented by one trade. Subdivision by trades, therefore, does not give ease or accuracy of measurement. A more suitable form of subdivision is to split this main item " geographically " into floors or in such a way that no single unit to be estimated exceeds 20 per cent. of the value of the whole structure. The geographical dividing lines must be obvious to the eye and carefully defined in the progress record.

The progress record form must be portable and easy to use in the field, so that the C.W. can record his observations thereon as he makes his monthly inspections. Subsequent computation of values can then best be done in the office. These requirements rule out systems of charts and indicate a tabular system of sheets in loose-leaf binders.

The use of the percentage system, as opposed to money values of subdivisions, facilitates slide rule work and reduces the number of columns to be added.

As each monthly estimate of work done on each subdivision is perforce in the nature of a guess, it is essential that any errors made are non-cumulative, but are automatically eliminated the following month. Consequently, do not attempt to estimate " how much work was done last month," but estimate " total work done to date."

SYSTEM USED.

The actual Progress Record forms used are as shown in Fig. 5. One of these sheets is prepared for each building or unit of the contract, on which the building is divided "geographically" as shown, and also a " Summary Progress Record" form, Fig. 8, for the whole contract. These, with a " List of Stores on Site" Fig. 7, are made up in a binder.

The total of each Progress Record Sheet represents that building or unit 100 per cent. complete and has its corresponding line on the

summary sheet. The total shown on the Summary is of course the contract total plus an allowance for deviations above contract, of which more later, and represents 100 per cent. of the " Job." The money values of the subdivisions are obtained from B/Q if there is one, otherwise by estimate, analogy from previous similar work or by certain subterfuges. An easy one is to get the contractor, who has tendered " lump sum " for the building, to fill in the blanks, making the total come to the contract price for the job or building in question. Detailed check of a few large items, *e.g.*, the cost of concrete work in a floor, will explode any attempt by an experienced contractor to extract overpayments on the early part of the work by submitting inflated values. Any small errors are automatically neutralized as the work proceeds.

The object of filling in the first two columns of figures in pencil is, of course, to allow the money values and percentages to be adjusted, if necessary, from time to time. Such adjustments are, however, best confined to the " Deviation " and " Summary " sheets, as this saves work and all alterations have in any case to be covered by deviation orders.

Deviations.

If a contract once placed never varied in scope, matters would be very simple. Many variations do, in fact, occur in practice, and a working system must cater for the numerous deviations made from time to time on the original contract. When a change is made to a building already in the contract, the deviation could be included by increasing the value of that building and its subdivisions concerned by the amount of the deviation. This system falls down, however, when a new building is added. A typical case: during construction of a barracks, it is decided to extend a Chinese barracks block and add a P.T. shed beside the school playshed. These deviations could be incorporated in the Progress system by either (*a*) amending the values for " Chinese Barrack Block " on the existing sheet and adding a new sheet for P.T. shed; or (*b*) including both items on a sheet entitled " Deviations," Fig. 6.

The latter method is preferred for several reasons. Providing the D.C.R.E. has guessed an adequate but not excessive figure for deviations, the percentages on the Summary sheet need never be varied. Each deviation order is entered on this sheet, its estimated value absorbing some of the balance for contingencies; consequently, deviation orders are kept under review and the balance in hand for further contingencies is always known. Moreover, it works with deviation deductions; if an item is cut out of the contract, the corresponding D.O. is entered as minus the value in question, and the balance in hand correspondingly increased. Also, deviations are in fact measured apart from the main contract, consequently there is no practical difficulty in progressing them in the same manner.

LISTS OF STORES ON SITE.

When handling large contracts the correct estimation of this item, worth sometimes as much as £20,000, is far more difficult than the estimation of progress of work. Heaps of broken stones and sand and untidy piles of steel bars lie scattered over the area; thousands of bags of cement, stacks of timber, crates of glass and multifarious other building materials lie hidden in matsheds or tucked away in half-finished buildings. Accurate stock-taking is impossible with the staff available and one method used is as follows: the contractor submits a claim for value of stores on site, showing quantities and prices. A fairly close check is made of the more valuable items, three or four at random being done in more detail than the others. Prices are checked against invoices, known market rates or prices claimed by other contractors, this last information being obtainable at once from the Progress Records for other contracts. The results, usually far below the contractor's figure, are condensed on the List of Stores sheet as shown.

PAYMENTS ON ACCOUNT.

The Progress Record binders are usually kept in the D.C.R.E. office, and are dispatched to G.E's in time for completion and returned by the 23rd of each month. Each large contract has its own binder; smaller fry, such as services costing £500 to £2,000, usually comprising one building or unit easily subdivisible on one sheet but big enough to be worth progressing in detail, are grouped in binders, one for each G.E.'s area. The List of Stores for such services are usually kept on the back of the respective Progress Records. G.E's usually prefer to keep a working copy of the Progress Records to carry about on the works. Some contractors make their own copies and follow up the monthly inspection with the utmost enthusiasm, others just take our word for it. Nobody can argue; the roof is on—half on—or off, for all to see, and the rest is very simple arithmetic. When the records come back completed by the G.E's, the F.C. extracts the estimates of value of work done and stores on site in pencil to a "monthly Payment on Account" form, Fig. 9. The D.C.R.E. then examines the records, compares them with his latest personal impression of the work in progress and agrees to or amends the G.E.'s estimates accordingly. A little judicious pessimism at this stage is the best and in fact the only effective spur to a dilatory Chinese contractor. When the amounts are finally agreed on, the F.C. then completes his calculations for payments on account and prepares the bills.

The Payment on Account form is a useful summary of affairs, providing monthly a birds'-eye view of all important work in hand, its value, progress to date and anticipated completion date. In addition, it forms the Finance Clerk's authority for the amounts shown on his bills.

Charts.

The system outlined above works without charts. The writer loves charts, preferably in several pretty colours; but (Alas!) there is no staff or time for them, except in the case of the largest services, where they are needed to estimate the trend of progress from July onwards, see Fig. 10. The dated spots on the line representing "Mar. 31" are the guesses of progress to the end of the year, made from time to time in the light of progress to the dates stated. Unfortunately the local war and a typhoon upset all calculations for a time, but the guesses were sufficiently accurate to be of some use. Here the writer must acknowledge his indebtedness to an old friend, Major W. J. Ross, O.B.E., R.E., whose Progress system employing "geographical" subdivision of units, as used in the construction of the Moascar cantonment 14 years ago, is the basis of the system now described. Major Ross, however, had a draughtsman and was able to plot the whole of his progress in chart form in many colours, with highly satisfactory results, artistic and otherwise.

Forecasting.

From about November onwards, fairly accurate forecasts of progress to April 1st can be made from the Progress Records as follows: Study the record line by line and guess what stage of completion will be reached by each item. Multiply out the percentages thus arrived at in the same way as usual, giving the expected value of work done. Then knock off ten per cent. for payment on account and another ten per cent. for unforeseen delays, "Chinese New Year" (ten days' blind), "Birthday of our No. 1 Mason" (*i.e.*, the God of Builders), rain out of season and so on. The answer gives more confidence than a wild guess at the job as a whole, and takes about ten minutes with a slide rule.

Conclusion.

The financial control system outlined above is one way of doing what anyhow has to be done on works services, *i.e.*, keeping track of what is going on now and forecasting what will happen in the future. It is better to have a definite procedure—not necessarily this one—than to rely on calculations on scraps of paper, hasty interviews at odd times with the Finance Clerk and on people's memories. Perhaps the chief points of the system outlined are, first, that everyone—D.C.R.E., Garrison Engineer and Finance Clerk—confines himself to his own work and overlapping and duplication are avoided; and second, that it is simple and at the same time sufficiently flexible to deal with the complications arising from a programme of work which is subject to frequent and sometimes drastic changes.

Note.—In the following figures, X . . . , Y . . . represent localities. M . . . , N . . . , O . . . , P . . . contractors.

(FIG. 1.)

Prelim. Estimate. *Form I, No. 26.*

Items { 10.C.I.176 .... } 13.12.37.

JOB: X . . .—OFFICERS' QR. TO SJTS.' MESS, SJTS.' MESS TO BARRACK BLOCK.

	$	£
1. T.C.work	—	
2. Contract, M . . . , less $220 unforeseen ...	19,500	
3. Deviations ordered	—	
4. Extras now foreseen—obscured glass in lavs., H. and C. rails, towel rollers, tiles in kitchen ...	340	
5. Externals—covered by contract	—	
6. Supervision and Day Labour—part-Chinese overseer, say 4 months at $20	80	
7. E. and M. labour	160	
8. E. and M. Stores—No. of points 74, incl. fans ...		140
9. C.W.'s Stores		60
10. Transport and misc. charges	—	
11. Contingencies: contract $220, D.C.R.E. $700...	920	
Exchange $ = 1/3	21,000	= 1,310
Sterling Total		£1,510

Devn. limit: 35%, say $26,600.

Completion: 6 months, 10.6.38. . . . . , G.E.

13.12.37.

(D.C.R.E.'s notes on reverse of this Estimate.)

		37/38.	38/39.	Total.
13.12.37.	Est. progress is :—			
	Convert Gp. V Qr. by 8.3. as contract	400	—	400
	Boys' Qr., re-roof as contract ...	90	—	90
	Sjts.' Mess, say start 1.3.39, pay ...	210	810	1,020
	Reqmts. are	£700	£810	£1,510
10.3.38.	Sjts.' Mess just started, cut to ...	£600	£910	£1,510

(FIG. 2.)

Final Estimate. *Form I, No. 26A.*

Items { 10.C.I.260 .... } 18.6.38.

JOB: X . . .—OFFICERS' QR. TO SJTS.' MESS, SJTS.' MESS TO BARRACK BLOCK.

		$	£
1. T.C. work—trial holes		20	
2. Contract, M . . . , less $220 unforeseen ...		19,500	
*3. Deviations ordered :—			
1. Renew door frames, billiard table support, lintels	$220		
2. Fan hooks, jalousies, kitchen H.W. system	210		
3. H. and C. hooks, towel rails, alter dresser	80		
4. Cupboard, move window	140		
5. Move 48" range	80		
6. Face part back wall	60		
7. Renew further door and window frames	60		
8. Move 54" range	60		
9. Partition abls./baths, fit bath ...	130		
10. Mosquito net wires...	10		
		1,050	
4. Extras now foreseen		—	
5. Externals, incl. in contract		—	
6. Supervision and D.L. \ 7. E. and M. labour /		290	
8. E. and M. Stores—74 points incl. fans \ 9. C.W. Stores / ...			177
10. Transport, misc.		40	
11. Contingencies remaining, say		168	
Exchange, $ = 1/3		21,068	= 1,323
Sterling Total			£1,500

Devn. limit: 35%, say $26,600.

. . . . . , G.E.

Completion: 1.7.38. 18.6.38.

* *Note.*—In contracts that are large enough to warrant progressing in the manner described in the paper, the D/O's are listed on the "Deviations" sheet of the progress record. Consequently there is no need to repeat them and the normal entry here would be :—

"3. Deviations ordered—Nos. 1 to 10 as Progress Record, $1,050."

(FIG. 3.)

Detailed Estimate. *Form I, No.* 155*B*.
Item 260. 21.8.38.

ITEM 260. ACCOMMODATION—LINK ESTIMATE.

Est. No.		*Detail.*	38/39. £	39/40. *on.*	Total. £
	Y . . .				
9D.	*a.*	N . . . , includes D/O.'s 1–53, incl. App. I items to C.R.E. 1773/2 d., 3.3.38, as follows :—			
		D/O. No.			
		(1) Chinese followers' Qrs. 8			
		(2) T.I. Room, increased size 10			
		(6) P.T. Shed for school 33			
		(8) Tiles in Bathrooms 18			
		(9) Mirrors in Abl. Rooms 30			
		(10) Part levelling and fencing 11	17,610	160	17,770
51.	*b.*	*Miscellaneous Firm Liabilities*, incl. 1st Barrack final bill, small contracts for hopper bolts, mantels, church furniture, (7) O . . . , T.C. orders to 8.38, and turfing, etc., deducted from *a.* on account of season	1,125	525	1,650
46.	*c.*	M . . . , (4), Regtl. shops ...	330	—	330
CRE.	*d.*	*Appendix I* remainder—Approved Services :—			
		(3) Decontamination Centre £470			
		(5) Welfare Centre ... £180			
				650	650
52.	*e.*	*Appendix II*—Services not yet approved, but necessary :— Board's recomdtns., extra tennis courts, and full scale of fittings in first contract bldgs. added to previous List	1,000	4,850	5,850
53.	*f.*	*Appendix III*—Desirable services	—	4,660	4,660
	g.	Contingencies remaining	—	90	90
		Y . . . Total	20,065	10,935	31,000
	X . . .				
36A.		W.O. Quarter	920	—	920
26A.		Gp. IV Qr. to Sjts.' Mess, Mess to Barrack	820	—	820
27.		Garages	100	—	100
28B.		Recreation Ground	550	—	550
47.		Parade Ground	650	—	650
		X . . . Total	3,040	—	3,040
		TOTAL, ITEM 260 ...	23,105	10,935	34,040

. . . . . , D.C.R.E.
21.8.38.

(FIG. 4.)

NOTES ON REVERSE OF COMBINED ESTIMATE 155B.

8.7.38. Spoke G.E. (A.). Assume—Y . . .—N . . . completes by 15.9., final bill by 15.3.39 therefore. (One-third reserve is £1,415.) X . . .—all *f.* bills this year, savings £204. Deduct from totals to get this year's requirements :—

		£	£
Y . . .	Appendix II items, not appvd. but necessary	4,350	
	Appendix III, desirable	4,660	
	Turfing rec. ground and other, in spring	£500	
	Contingencies, say	631	
			10,141
X . . . , savings			204
Total deductions			£10,345

	38/39.	39/40 on.	Total.
	£	£	£
Requirements on item ...	22,200	10,345	32,545

19.7.38. C.R.E. spoke. Is adding R.E. Office, Appendix II item, £400, to appvd. services this year, say three-quarters complete by 31.3.39.

Requirements on item ...	22,500	10,045	32,545

10.8.38. C.R.E. agreed that revision of estimate on this item can wait till next month as most of deviations on N . . . contract will be measured.

(Fig. 5.)

CONTRACT ACCEPTED ...../...../.....

COMPLETION * ...../...../.....

* PENCILLED FIGURES.

Form 2

ORIGINAL VALUE $ *94,410*

VALUE ON * / / $ .....

CONTRACTOR *N . . .*

VOTE PT. SERVICE *Y . . . , M.S. Qr., No. 3 Block.*

PROGRESS RECORD NO. *8.*

ITEM *8, 9 of Contract.*	* VALUE ON / / * $	* VALUE ON / / * %	% COMPLETION 22/11/37 Item	22/11/37 Total	21/12/37 Item	21/12/37 Total	21/1/38 Item	21/1/38 Total	22/2/38 Item	22/2/38 Total	31/3/38 Item	31/3/38 Total	25/4/38 Item	25/4/38 Total	21/5/38 Item	21/5/38 Total	23/6/38 Item	23/6/38 Total	21/7/38 Item	21/7/38 Total	19/8/38 Item	19/8/38 Total	/ / Item	/ / Total	/ / Item	/ / Total
Excavation, Founds., Ground Floor, fill and surface	*6,750*	*7·1*	*20*	*1·4*	*75*	*5·3*	*75*	*5·3*	*85*	*6·1*	*100*	*7·1*	*100*	*7·1*	*100*	*7·1*	*100*	*7·1*	*100*	*7·1*	*100*	*7·1*				
Columns, 1st Floor and Railings	*19,000*	*20·1*			*5*	*1·0*	*60*	*12·1*	*90*	*18·7*	*100*	*20·1*	*100*	*20·1*	*100*	*20·1*	*100*	*20·1*	*100*	*20·1*	*100*	*20·1*				
Columns, 2nd Floor and Railings	*18,500*	*19·6*							*10*	*2·0*	*93*	*18·2*	*95*	*18·6*	*100*	*19·6*	*100*	*19·6*	*100*	*19·6*	*100*	*19·6*				
Columns, Roof and Parapet	*18,410*	*19·5*									*26*	*4·8*	*90*	*17·5*	*92*	*17·9*	*95*	*18·5*	*100*	*19·5*	*100*	*19·5*				
Brick Panel Walls and Wood Frames	*11,000*	*11·7*				*1·8*	*20*	*2·3*	*30*	*3·5*	*60*	*7·0*	*90*	*9·9*	*100*	*11·7*	*100*	*11·7*	*100*	*11·7*	*100*	*11·7*				
Steel Doors and Sashes	*9,850*	*10·4*											*25*	*2·1*	*50*	*5·2*	*90*	*9·4*	*100*	*10·4*	*100*	*10·4*				
Rendering, internal and external	*1,750*	*1·9*									*30*	*·6*	*75*	*1·3*	*90*	*1·7*	*98*	*1·8*	*98*	*1·8*	*100*	*1·9*				
Plumber and Ironmonger	*2,200*	*2·3*											*25*	*·5*	*70*	*1·6*	*90*	*2·1*	*95*	*2·2*	*95*	*2·2*				
Floors, teak and tile	*2,200*	*2·3*											*30*	*·7*	*35*	*·8*	*40*	*·9*	*80*	*1·3*	*100*	*2·3*				
Back Staircases (3) complete	*1,200*	*1·3*							*20*	*·4*	*60*	*·8*	*75*	*1·0*	*80*	*1·0*	*100*	*1·3*	*100*	*1·3*	*100*	*1·3*				
Joinery and Fittings	*1,200*	*1·3*											*80*	*1·0*	*82*	*1·0*	*82*	*1·0*	*95*	*1·2*	*100*	*1·3*				
Decorations and Finishings	*400*	*0·4*											—	—	—	—	—	—	—	—	*100*	*0·4*				
External—Drains, Path, Level	*1,950*	*2·1*	*10*	*0·2*	*20*	*0·4*	*20*	*0·4*	*20*	*·4*	*40*	*·8*	*45*	*0·9*	*45*	*·9*	*80*	*1·7*	*85*	*1·8*	*100*	*2·1*				
Deviations—see Dev. Sheet for main contract (Fig. 6)	—																									
TOTAL	*94,410*	*100·0*		*1·6*		*8·5*		*20·1*		*31·1*		*59·0*		*80·7*		*88·6*		*95·2*		*98·5*		*99·0*				
D.E.F.				*22/11/37*		*21/12/37*		*21/ 1/38*		*22/ 2/38*		*25/ 3/38*		*25/ 4/38*		*21/ 5/38*		*23/ 6/38*		*21/ 7/38*		*19/ 8/38*		/ /		/ /

EST. TOTAL CONTRACT WORK DONE $

EST. VALUE OF STORES ON SITE $

G.E.'S INITIALS & DATE

As this building is one item in a large contract % completion only is carried forward. See Fig. 8. Stores on site on separate sheet for whole contract, Fig. 7.

(Fig. 6.)

CONTRACT ACCEPTED ...../...../.....
COMPLETION * ...../...../.....

* PENCILLED FIGURES.

Form 2

ORIGINAL VALUE $ .....
VALUE ON * / / $ .....
CONTRACTOR *N . . .*

VOTE PT. SERVICE *Barracks II—Deviations above Contract.* PROGRESS RECORD NO. .....

ITEM		* VALUE ON / /		% COMPLETION / /		21/7/38		19/8/38		/ /		/ /		/ /		/ /		/ /		/ /		/ /		/ /		/ /	
		* $	* %	Item	Total	Item	Total	Item	Total	Item	Total	Item	Total	Item	Total	Item	Total	Item	Total	Item	Total	Item	Total	Item	Total	Item	Total
6	*Qrs.—Turfing*	2,870	11·1			100	11·1	100	11·1																		
13	*Roof—aller Drainage*	870	3·3			100	3·3	100	3·3																		
18	*M.O. Qrs.—Tiled Dados, E.L. Cable Trench, Guard Bars*	3,030	11·7			100	11·7	100	11·7																		
19, 23	*Institute Partition*	960	3·7			95	3·5	100	3·7																		
21	*Qrs.—Showers*	1,590	6·1			95	5·8	100	6·1																		
22	*Offices—Hot-water System*	1,480	5·7			—	—	50	2·9																		
25	*Bks. 1 and 3—Partitions, two-roof purpt., varnished teak, Shop Alteration*	3,700	14·3			80	11·5	100	14·3																		
26	*Hydrants, Chinese W.C. Drain*	1,800	7·0			40	3·2	100	7·0																		
28	*Mess, Excav. Hall, Rec. Gd. Excav.*	900	3·5			50	1·7	100	3·5																		
32, 34, 35	*Addl. P.C. item 55, divert Main*	410	1·6			90	1·4	100	1·6																		
33	*Addl. P.T. and Playshed. B.M. Store—divert Drain*	2,000	7·7			70	5·4	100	7·7																		
36, 37	*Mess—cleaning room*	240	·9			50	·4	100	·9																		
38	*Bk. 3—Chinese Accomdtn.*	700	2·7			—	—	100	2·7																		
39	*Church—addl. Partition, Mosquito Wires, P.A.C. Plumbing*	380	1·5			100	1·5	100	1·5																		
40, 44, 50	*Institute—addl. Partition*	470	1·8			—	—	60	1·0																		
41	*Rec. Gd.—divert Main*	670	2·6			—	—	100	2·6																		
42, 43, 45	*M.S.Q.H. bank, Bk. 1, ditto, Church ditto*	1,250	4·8			—	—	80	3·8																		
47	*2 Septic Tanks*	8,100	31·2			—	—	60	18·7																		
−48, 51−	*Deduct School Fence, Turfing*	−8,300	−32·0			—	—	−100	−32·0																		
49	*Mess—widen Approach Road*	240	·9			—	—	80	·7																		
53	*Repair Wardrobes—Pt. III*	1,000	3·8			—	—	80	3·2																		
	Contingencies remaining	1,580	6·1																								
	TOTAL	25,940	100·0				60·5		76·0																		
EST. TOTAL CONTRACT WORK DONE			$																								
EST. VALUE OF STORES ON SITE			$																								
G.E.'S INITIALS & DATE				/ /		/ /		/ /		/ /		/ /		/ /		/ /		/ /		/ /		/ /		/ /		/ /	

Previous Monthly Records omitted from example

NOTE.—The total, $25,940, is decided on as described in the paper. D/O's are added to this list as they are placed, each one resulting in a corresponding deduction in "Contingencies remaining." Conversely, the effect of D/O. 48 and 51 was to increase the "Contingencies remaining" by $8,300 in this case.

Form 3.

(FIG. 7.)

STORES ON SITE.

Service: X . . . *Contractor:* P . . .

Item.	Value. $	Stock Verified. Amount. 23/2/38	Value. 23/2/38	Amount. 31/3/38	Value. 31/3/38
Sand ... ... Y.C.	1·50	2,000	3,000		
Granite aggregate ... Y.C.	1·40	4,000	5,600		
Cement, G.I. ... 90-lb. bag	·90	10,000	9,000	Further monthly records omitted from the example.	
Casing for p.c.c.... ... sqrs.	13·00	100	1,300		
Sika ... ... gall.	10·00	390	3,900		
Timber, scantlings ... f.r.	·10	10,000	1,000		
Bricks ... ... per 1,000	25·00	5,000	125		
P.c.c. pipes, 3"... ... f.r.	·16	500	80		
„ „ 12"... ... f.r.	·70	150	105		
Asphalt, invoice ... ton	130·00	15	1,950		
Roofing felt ... ... roll	6·00	100	600		
Steel windows ... ... inv.		lot	750		
Gunmetal ware ... ... inv.		lot	920		
Steel, ½"-bars ... ... ton	300·00	80	24,000		
„ ¾"-bars ... ... ton	300·00	240	72,000		
„ channel sects. ... cwt.	25·00				
TOTAL			124,330		
Est. Value of Stores on site ...	$	say	124,000		
G.E.'s initials and date ...		D.E.F. 23/2/38			

(FIG. 3.)

Form 2.

CONTRACT ORDERED *26/4/37*
COMPLETION * *1/9/38*

SUMMARY
PROGRESS RECORD No.....

ORIGINAL VALUE $ *1,359,500*
VALUE ON * *21/8/38* $ *1,387,000*
CONTRACTOR *N . . .*

VOTE *176* PT. *I* SERVICE *Y . . . Barracks II.*

Contractor's Estimate No.	ITEM	*VALUE ON 20 / 8 / 38		% COMPLETION 21/10/37		22/11/37		21/12/37		21/ 1/38		22/ 2/38		31/ 3/38		25/ 4/38		21/ 5/38		23/ 6/38		21/ 7/38		19/ 8/38		19/ 9/38	
		* $	* %	Item	Total	Item	Total	Item	Total	Item	Total	Item	Total	Item	Total	Item	Total	Item	Total	Item	Total	Item	Total	Item	Total	Item	Total
2, 3	Barrack Block No. 1	135,740	9·76					53·7	5·36			75·4	7·43											99·9	9·75		
4, 5	Barrack Block No. 3	141,510	10·18					11·2	4·28			56·2	5·76											99·9	10·17		
6, 7	M.S. Qrs., Block No. 2	93,970	6·76					74·0	5·12			80·2	5·47											100	6·76		
8, 9	M.S. Qrs., Block No. 3	94,410	6·80					8·5	·59			31·1	2·13											99·9	6·79		
10, 11	M.S. Qrs., Block No. 4	105,300	7·58					20·1	1·56			55·9	4·28											100	7·58		
12, 13	W.O.'s, 3 Qrs.	47,970	3·45					41·8	1·47			61·5	2·15											99·9	3·44		
14, 15	Sp. V, 2 Qrs. No. 4	51,840	3·73					47·5	1·81			67·7	2·55											100	3·73		
16, 17	Gp. V, 2 Qrs. No. 5	51,820	3·73	*These and previous*				68·8	2·63	*Omitted*		75·4	2·83	*Monthly Readings omitted*										100	3·73		
18, 19	Gp. V, 2 Qrs. No. 7	59,380	4·28	*Monthly Records*				38·5	1·68			55·2	2·38											99·9	4·27		
20, 21	Gp. V, Qr. No. 6	29,720	2·14					57·0	1·24			68·0	1·46											99·7	2·13		
22, 23	Gp. IV, Qr. No. 2	29,130	2·10	*Omitted*				71·4	1·52			77·9	1·64	*from the example*										100	2·10		
24, 25	Gp. IV, Qr. No. 3	28,870	2·08					58·2	1·24			72·2	1·51											100	2·08		
26, 27	Gp. IV, Qr. No. 8	32,340	2·33					56·9	1·35			67·5	1·58											99·9	2·32		
28, 29, pt. 55	Officers' Mess	213,790	15·36					55·5	8·73			71·5	11·08											99·7	15·35		
30, 31	Institute	62,930	4·51					72·6	3·36			77·0	3·51											100	4·51		
32, 33, 52, 53, 54, pt. 55	Church & Lecture Rm.	34,270	2·47					52·0	1·31			59·7	1·48											99·9	2·46		
34, 35, 36,	School & Play Sheds	23,890	1·72					9·7	·17			35·4	·61											99·9	1·72		
37, 38, 43-46	Coal Yd., Native Lat., Brad. S.	6,040	·43					50·2	·22			54·4	·24											100	·43		
39, 40	Range & T.I. Room	7,300	·53					66·8	·37			72·6	·38											100	·53		
41, 42	Grd. Rm. & Groc. Bar	24,850	1·79					35·3	·65			61·5	1·11											100	1·79		
50, 51	Playing Fd. & Pde. Gd.	55,000	3·96					20·9	·92			29·9	1·19											76·9	3·04		
1, 56	Prelim. 4,500, Contings 25,000	37,000	2·22					60·0	1·30			72·0	1·54											97·8	2·17		
—	Decn. above Contract	25,940	1·87									14·3	·21											76·0	1·43		
—	Ret. to adjust Decns.	3,000	·22																								
	TOTAL *	1,390,000	100·00		26·23		37·34		46·88		56·74		62·52		79·3		86·5		90·81		93·14		95·31		98·19		
EST. TOTAL CONTRACT WORK DONE			$	350,500		507,100		637,200		782,500		862,500		1,095,000		1,193,700		1,253,200		1,285,300		1,315,300		1,362,000			
EST. VALUE OF STORES ON SITE			$	207,000		222,100		241,100		282,100		205,300		162,500		93,000		33,100		42,600		11,500		—			
G.E.'S INITIALS & DATE				/ /		/ /		/ /		/ /		/ /		/ /		/ /		/ /		/ /		/ /		/ /		/ /	

* *Note Original Value* $1,359,500
Issued 11/1/38 to $1,380,000
Issued 16/5/38 to $1,390,000

(FIG. 9.)

MONTHLY PAYMENTS ON ACCOUNT FORM—20TH MARCH, 1938.

CONTRACT.	Paid to last Return.	Latest: Contract Value.	Latest: Cmpl. Date.	Value of Work to Date.	Value of Stores on site.	Makes total Payments to date.	% Cmpt. tn.	Bill in March. $
Barracks, S.	947,200	1,374,760	30.7.	1,095,000	162,000	1,124,220	79	177,020
Contract L.	357,600	565,120	21.7.	392,000	97,000	422,310	66	64,710
Contract C.	54,900	203,440	22.6.	70,000	46,000	90,600	31	35,700
Contract D.	12,780	15,090	21.4.	15,130	—	13,620	99	840
Contract J.	104,100	405,690	9.9.	108,000	102,000	158,400	30	54,300
Contract H.	99,000	262,670	8.5.	159,000	9,500	148,800	61	49,800
Sisters' Qrs. Site ..	6,930	8,000	31.3.	8,700	—	7,830	99	900
X . . . , Sjts.' Mess ..	5,400	20,075	9.6.	8,500	1,550	8,600	43	3,200
Rec. Ground ..	2,340	10,520	7.4.	3,200	2,200	4,200	30	1,860
Garages ..	3,470	8,900	21.3.	8,500	—	7,650	95	4,180
Z . . . , Garages ..	6,050	15,430	28.3.	15,500	—	13,950	99	7,900
Period, Painting ..	3,480	19,240	11.4.	11,000	1,200	10,620	62	7,140
Y . . . , Road Surface	1,190	7,470	14.2.	6,500	170	5,950	82	4,760
Contract FS.	2,660	12,020	12.3.	6,100	2,000	6,700	57	4,040
Z . . . , M.I. Rm. ..	8,460	16,330	3.4.	14,700	—	13,230	90	4,770
Contract CR.	7,290	7,439	—	9,000	—	8,100	99	810
Contract CH.	23,090	37,530	31.3.	31,000	700	28,320	85	5,230
Contract A.	2,120	56,800	21.8.	16,000	2,500	15,900	30	13,780
W . . . , Roof ..	1,815	17,940	8.5.	6,700	1,500	6,930	36	5,115
Contract E.	—	6,920	8.3.	1,600	250	1,590	22	1,590
X . . . , W.O. Qr. ..	—	14,630	3.6.	1,400	1,400	2,100	9	2,100
T.C. 1318, Huts ..	1,890	9,200	10.4.	7,650	—	7,240	95	5,350
T.C. 1190, St. Trench	—	909	28.3.	600	—	540	60	540
T.C. 1157, St. Roof ..	—	1,300	15.4.	900	—	810	65	810
St. Hopper Bolts ..	—	900	4.4.	225	60	240	25	240

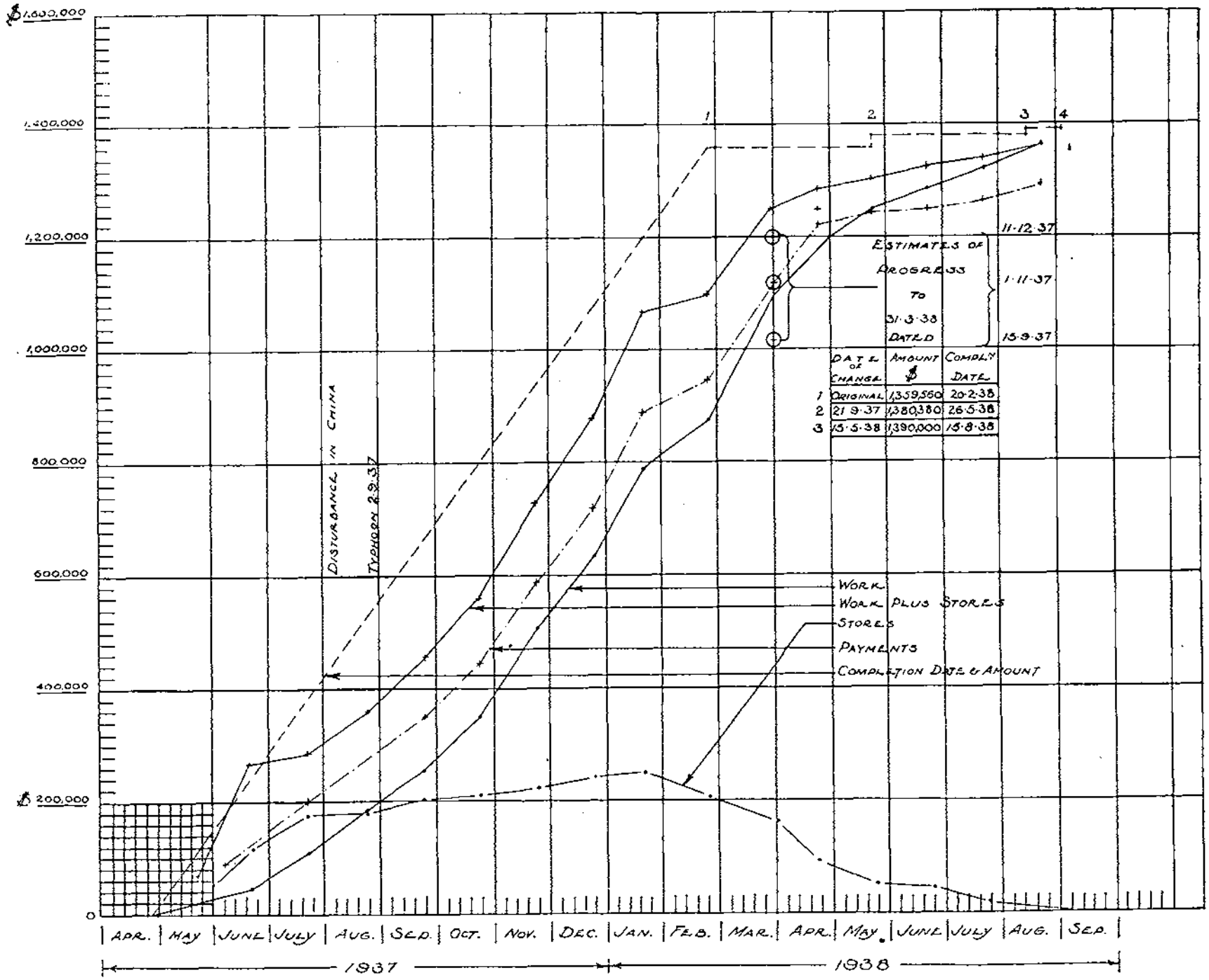
NOTE.—*The error brought to light in Item 7—work done greater than orders placed.* The Monthly Expenditure on account is about £30,000 spread over 25 contracts and larger T.C. orders.

1Y ..... CONTRACT ..... N .....

ACCEPTED 21·4·37 FOR £1,359,560

ORDERED 26·4·37

(FIG. 10)



OLD FORT HENRY AT KINGSTON, ONTARIO.

By RONALD L. WAY, M.A.

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KINGSTON, Ontario, the old Cataraqui or Fort Frontenac of the French and one-time capital of Canada, has as its most conspicuous feature a picturesque old fort, which is located upon a commanding promontory overlooking the harbour. Just one hundred and two years ago, in 1836, the main portion of the present fort was completed and two batteries of Royal Garrison Artillery and one regiment of the line took possession.

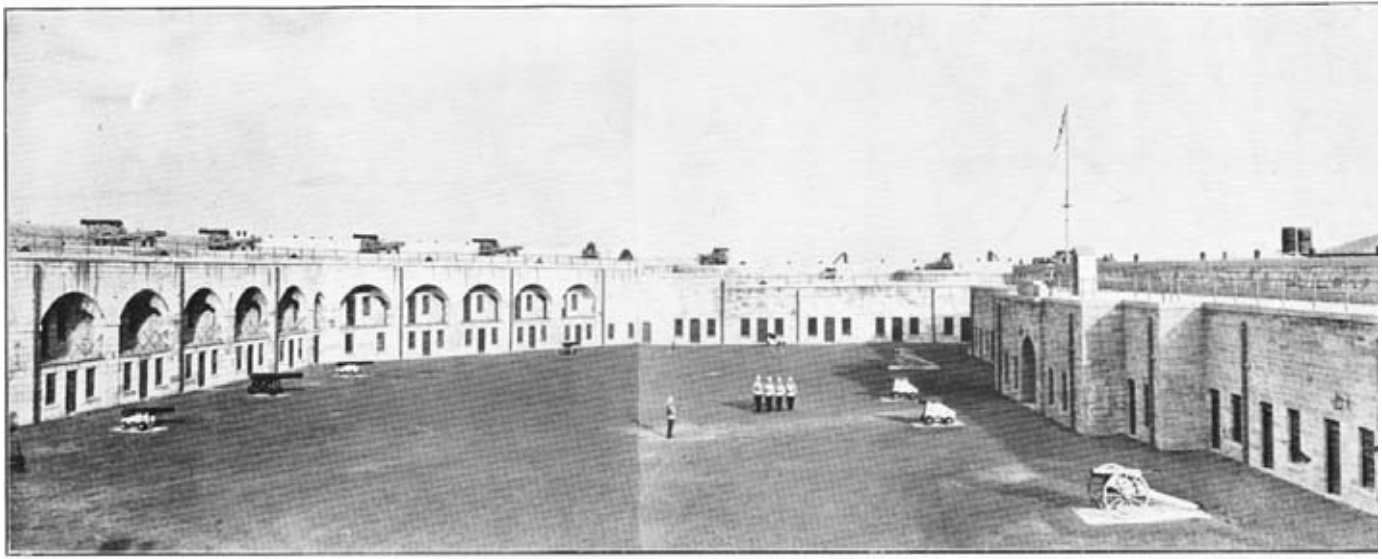
During the war of 1812, Kingston, as the base of the British Naval Establishment on Lake Ontario, was in a military as well as a naval sense the most important strategic position in Upper Canada. As long as Kingston was held securely and the communications with Montreal kept open, the necessary materials for the equipment of war vessels could be forwarded from Britain and the supremacy of the Lake contested with the Americans. Upon this command of Lake Ontario depended the security of the country as far as Niagara and the means of dispatching troops and supplies for the defence of the Niagara frontier and the country farther west. The Naval Establishment occupied the long narrow peninsula just west of Fort Henry, and in May, 1813, the site of the present fort was cleared of trees and an entrenched battery of six 24-pdr. guns was set up for the defence of the dockyard. Later in the same year, the battery was completely enclosed and the earthworks revetted with logs. In 1814, two stone blockhouses, each 50 feet square, were constructed within the ramparts and picketing set up in the bottom of the ditch. Between 1815 and 1820, the logs sustaining the walls of the ditch were replaced by stonework, and the addition of bomb-proof magazines, ordnance offices, an armoury and extensive stone barracks, made this first Fort Henry the strongest post west of Quebec.

The necessity of securing an alternative and safer means of communication between Montreal and Kingston, than that provided by the St. Lawrence River route was demonstrated by the war of 1812. Upon the recommendation of the Duke of Wellington, after preliminary surveys had proved the project feasible, the military authorities decided to reconstruct the Rideau Canal connecting the

waters of the Rideau River, flowing into the Ottawa, with those of the Cataraqui emptying into the St. Lawrence at Kingston. The building of the Rideau Canal further increased the strategic importance of Kingston, and the then existing defences were considered inadequate for the protection of the entrance of the canal. In 1828 a military committee, of which His Excellency, Sir James Kempt, the Governor of Lower Canada, was president, in the course of a report dealing with progress made in the construction of the Rideau, recommended the erection of a system of six detached forts—three on each side of Kingston harbour—designed to keep an enemy from 2,300 to 2,700 yards distant from the naval dockyard, and the entrance to the canal. Experience during the war of 1812 had indicated that a hostile force would move against Kingston from the land side and the forts should be designed to resist a regular siege from that direction. Defence of the harbour in the face of a purely naval attack would be taken care of by a system of martello towers constructed at half-mile intervals. In October of the following year, 1829, a Committee of the Board of Ordnance in England, headed by Sir Alexander Bryce, approved the recommendations of the Committee of 1828, and drew up the plans of a new Fort Henry, the five other redoubts and the martello towers. Of these the present Fort Henry with its Advanced Battery and four martello towers were the only units of the system constructed. Complete estimates and plans for the five other forts—very similar in design to Fort Henry—were prepared and negotiations carried on for the purchase of the necessary sites; however, as relations with the United States improved, opposition to the increased cost of Colonial Defences, led the British House of Commons to refuse the funds necessary to complete the fortifications of Kingston.

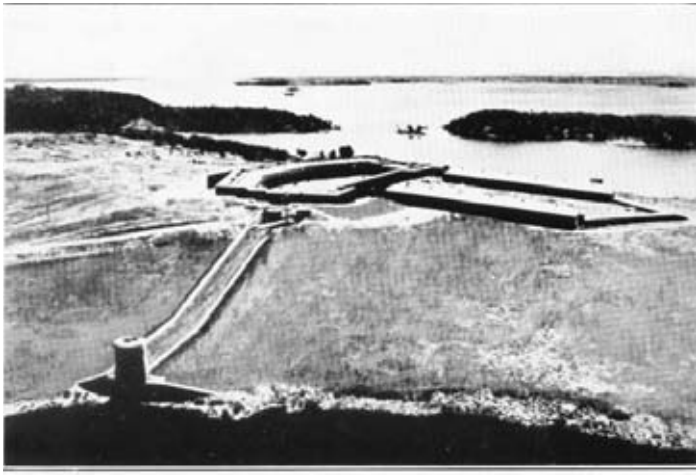
Only through an understanding of the scheme of defence adopted by the Engineer Committees of 1828 and 1829 is the structure of Fort Henry fully comprehensible to-day. Sprawled across the crest of the high peninsula upon which it was built, the main portion of the fort consists of a pentagonal figure, the three-sided front of which faces inland towards the north and completely covered the Rideau entrance and the Naval Establishment against attack from that direction. The entrance to the fort is on the south side through the Advanced Battery and the Commissariat Stores, which, while included in the plans of 1829, were not completed until 1842. Built into the walls of the fort are long and narrow-vaulted shellproof casemates, which served as barracks for officers and men. The casemates on the front faces, in which the ordinary soldiers were quartered, consist of two tiers; those on the side faces, which were occupied by the officers, have only one tier. The chief armament was mounted upon the ramparts above the casemates and consisted of 27 24-pdr. guns upon traversing platforms which allowed them to be turned with ease

OLD FORT HENRY AT KINGSTON, ONTARIO.



Interior view of Fort Henry.

Old Fort Henry at Kingston, Ontario - Interior view



Fort Henry.

West Ditch Tower.

Old Fort Henry Kingston, Ontario - Fort Henry & West ditch tower

in any direction required. Surrounding the principal part of the fort is a dry ditch approximately 40 feet broad and 30 feet deep, the counterscarp of which effectively screened the walls from gun-fire. The walls are flanked by a caponier in the centre of the north front and by gun-rooms—known technically as reverse-fire chambers—built in behind the counterscarp in the north-east and north-west angles of the ditch and connected with the fort by tunnels. Branch ditches extend down to the shores on either side of the peninsula, where they terminate in strong martello towers 60 feet in height and 30 feet in basal diameter. Swept by the fire of Fort Henry and the Martello towers, these ditches served as obstacles to an enemy approaching the south side of the fort. The whole peninsula was thus a compact defensive unit and constituted the first sector of the chain of forts planned for the protection of Kingston.

Although never attacked by an enemy, the history of Fort Henry has not been lacking in colourful incidents. In February, 1838, an American, Van Rensellaer, who was in sympathy with the Canadian rebels, formed a plan for an attack upon the fort. A traitor among the garrison had agreed to spike the guns, and even to open the gates upon the approach of the " Patriots." The plan leaked out and when 1,600 militia were placed in Fort Henry, an American force of 1,800 men, which had taken possession of Hickory Island near Gananoque, melted away.

In the guardhouse of Fort Henry, during November of the same year, was confined the misguided Von Schultz who, with about 160 men, crossed the St. Lawrence at Prescott and after four days' fighting was captured by Colonel Dundas and a force from Kingston. After being tried by court-martial he was hanged at the north-west corner of the fort. Here also were imprisoned John Montgomery and fourteen others, who were captured after the skirmish at Montgomery's Tavern and placed in Fort Henry under sentence of death. The party was confined in a casemate, separated by a 4-foot wall from one of the passages leading down under the ditch to the reverse-fire chambers. As the mortar in the wall was not quite dry, the men patiently loosened the stone separating them from this passage-way and succeeded in making their escape. In climbing from the reverse-fire chamber into the ditch, Montgomery broke his leg but, in spite of this and other difficulties, the men made their way to Cape Vincent, where they were accorded a civic welcome.

The gradual betterment of relations with the United States combined with military development of the late nineteenth century, slowly to decrease and finally to nullify the importance of Kingston's defences. At the time of the North-West Rebellion in 1885, Fort Henry was considered to be of little value and was soon afterwards abandoned as obsolete, the garrison being removed to quarters in Kingston. As the fort grew old and fell into decay, local legends

enshrouded it. The plans of the Royal Engineers responsible for its design naturally had not been made public and in so technical a matter the speculations of amateurs, unsupported by documentary evidence, are poor substitutes for facts. Some have said that Fort Henry was built the wrong way round, the plans having been confused with those for a fort at Kingston, Jamaica; others, that the engineer responsible for the mistake was on that account cashiered out of the army after his return to England—or again that he committed suicide on his way there. It was commonly believed that deep underwater tunnels led from Fort Henry to the martello tower at Point Frederick, to Cathcart Redoubt on Cedar Island and to the Military Hospital, the ruins of which may be seen a short distance to the north-east of the fort. The builders of 1832–36 would certainly have smiled at such tales.

While it may be said that Fort Henry has never fired a gun in battle, it has nevertheless strong claims to preservation. In the first place, there is the obvious desire of all those possessing any sense of history or fondness for antiquities, to save for the future this excellent specimen of early nineteenth-century fortification, which is one of the finest examples of masonry on the North American continent.

The site is replete with historical associations, and has been a military reserve since 1784. Navy Bay, overlooked by the guns of the Fort, was a hive of activity during the war of 1812. More than twenty men-of-war were built in the Naval Dockyard, where the Royal Military College now stands, and the shores of Navy Bay were once busy with the hauling of huge oak timbers and resounded to the clank of massive chains and munitions of war, the strokes of hammers and caulking irons, and exultant cheers rose as ship after ship was launched upon the waters to add strength to His Majesty's Lake Ontario Navy. The Fort was a centre of military life for more than half a century. Kingston belles can still remember dances in the old Officers' Quarters and tennis parties in the lower square. Imperial troops were stationed there from 1836–1870 and native Canadian troops more or less regularly from 1870–1890. People are still alive who were born within its massive walls. In military language, Fort Henry is a casemated redoubt with caponiers and reverse-fire chambers as flanking devices in place of the usual bastions. Both in design and massive construction Fort Henry is unlike any other fort ever built in Canada.

The work of restoration, which has been in progress since the summer of 1936 under a joint scheme sponsored by the Dominion and Ontario Governments, is almost complete. Although the fort to-day has the appearance of an impressive fortress, bristling with mounted cannon and defended by glacis, ditch, drawbridge, caponier, reverse-fires, flanking towers, and all the paraphernalia of nineteenth-century fortification, it is no more than a museum. It

is not in any way a renewed citadel nor intended to be one and its guns, strictly appropriate to their periods, are as useless as Roman catapults for or against modern attack. The casemates which once sheltered 350 men now serve only to house illuminating collections of antique weapons or to show how soldiers of a century ago lived and toiled. The museum proper displays separate and specialized collections of infantry, cavalry, artillery and naval arms and equipment. Much of the material in the Naval Museum is especially interesting, having been salvaged from the wrecks of the war vessels of 1812, which lie sunk in Navy and Dead Man's Bay. The officers' quarters, one of the soldiers' barrack rooms, the guard and orderly rooms, kitchen, etc., are refurnished as they were lived in by troops of 1838.

To Canada's American friends, always welcome guests, Kingston's past defences must remain an indirect compliment to the energy, ambition and resources of their forefathers, whose ignorance of Canadian sensibilities made their ideas upon "Manifest Destiny" excusable enough. But for Canadians themselves a restored Fort Henry will long stand as a vivid reminder of those long years of tutelage when Britain, not without parental grumbling it is true, freely gave the lives and services of her sons and spent lavishly of her treasure in order that this youthful nation might grow up unhampered and be free.

BOMB DAMAGE AND REPAIRS ON THE KAN SUI BRIDGE, CANTON–KOWLOON RAILWAY.

By COLONEL G. C. GOWLLAND.

THE following is a short account of the effects of a 500-lb. bomb on the Kan Sui railway bridge in South China, and the subsequent repairs carried out by the staff of the Canton-Kowloon Railway.

This bridge, which was built in 1910, consists of three spans of 100 feet and is situated about 38 miles from Canton. The abutments are built on 12 inch by 12 inch timber piles, and the piers on circular well curbs 26 feet 6 inches in diameter, sunk to a depth of 60 feet below low water level.

During the attack, only one hit was scored and this was on the south end of No. 1 Pier about 4 feet below the water line. The figure gives a cross-section of this pier. The Japanese bombers flew across the bridge and not along its length, thus making it harder to get hits.

The damage above the water line can be seen in photographs 1, 2 and 3. The widest cracks were some 9 inches wide and extended right through the pier. The north bearing-plates of No. 1 and No. 2 spans were moved 9 inches out of line.

There was also a horizontal crack right across the pier where the bomb struck. This is below water level and not visible in the photographs.

Temporary repairs were carried out and the results are shown in photographs 4, 5 and 6. The repairs were done by erecting 40 vertical pieces of decauville rails (12 lb.), and then binding them with rings of angle iron. This was the quickest way of getting the masonry bound together. Hardwood packing pieces were inserted under the rail bearers so as to distribute the load. By this means locomotives and vehicles were passed over the bridge 76 hours after the attack. Later, the cracks were filled with cement grout.

The whole pier is built of mass concrete 1.3.6 and in view of the damage it is interesting to note that in the completion report of the bridge it is stated that " The piers were brought up in ' lifts ' of 4 feet to 7 feet, the same shuttering being used again and again." These " lifts " are clearly seen in photographs 2 and 3, and in every case the cracks follow the joints in the work, showing that the concrete was not bonded.

The writer has been unable to obtain any evidence of the effect of bombs on reinforced-concrete bridges and piers. There is none on the local railway, but it is obvious that damage to the piers of a reinforced-concrete structure under similar bombardment would have been very much less than was the case in this particular instance.

Photo No. 1.—General view. Arrow shows approximate position of bomb.

Photo No. 2.—Hong Kong or east face of No. 1 Pier. Arrow shows position of bomb.

Photo No. 3.—Canton side of pier, or west face.

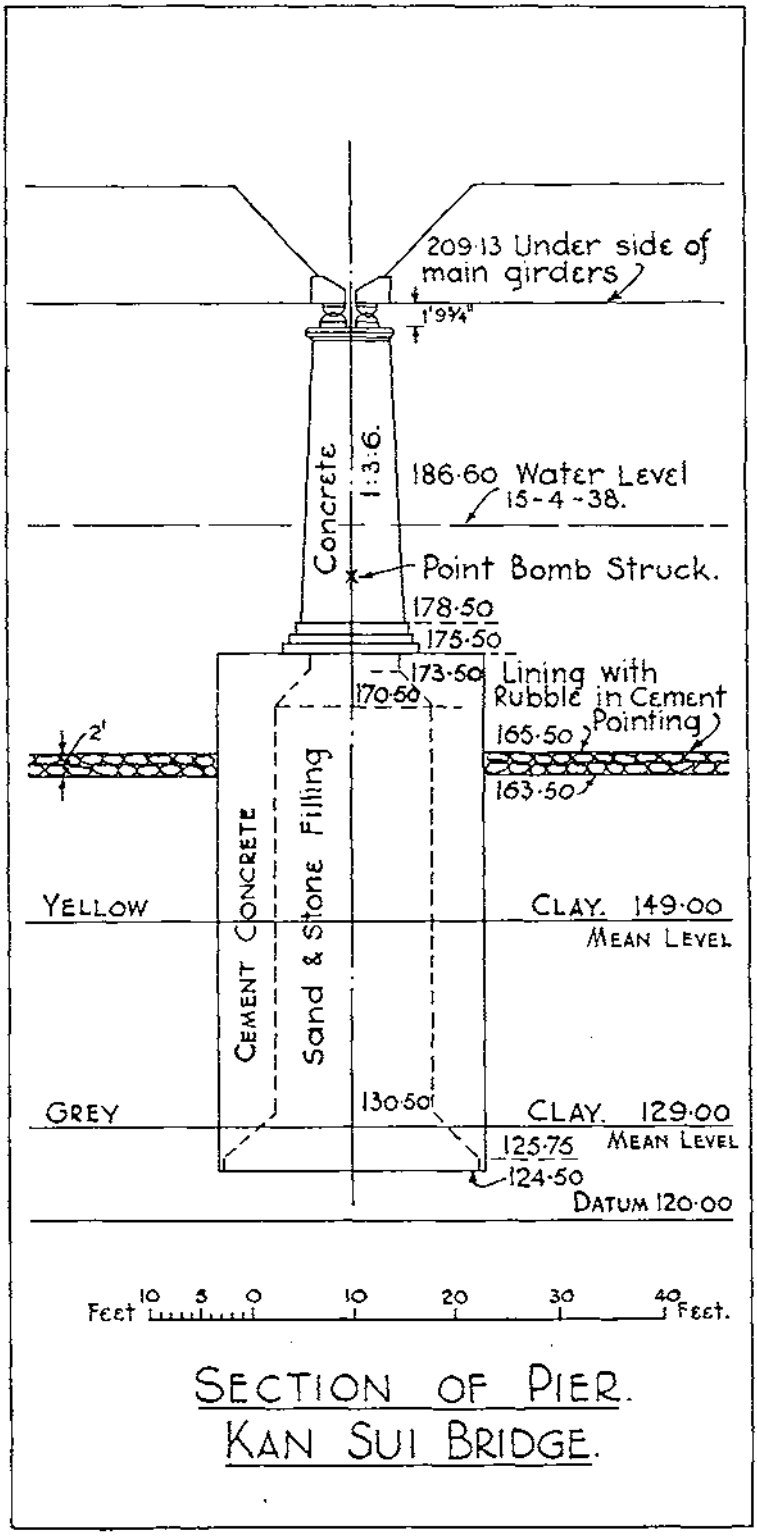
Bomb damage & repairs on Kan Sui bridge 1, 2 & 3

Photo No. 4 —N. side of Pier No. 1

Photo No. 5.—Canton face, No. 1 Pier.

Photo No. 6.

Bomb damage & repairs on Kan Sui bridge 4, 5 & 6



SECTION OF PIER.
KAN SUI BRIDGE.

THE BUILDING OF "PRELUDE."

By LIEUTENANT J. M. L. GAVIN, R.E.

Prelude is a yacht.

She is a five-ton Bermudan sloop with an overall length of 36 ft. and sleeping accommodation for five; she is an unusual yacht for she was "home-made," built by a syndicate consisting of two Sapper officers, one Signals officer and a friend in business in London; and she was built as far away from the sea as Gibraltar Barracks, Aldershot, in the winter of 1937–38. She is an unusual yacht, for her starboard deck is half an inch wider than her port deck, she has a rusty spanner built into her bilge and one of her ribs is sawn through by mistake. But she floats and sails, and we understand that even professionally-built yachts are not always entirely free from these defects. After all, it is something to know about them.

The idea of building a boat began quite casually in the summer, while Millis Jefferis and I were sailing together. By the time that the 1st Field Squadron were encamped on Windmill Hill for manœuvres the idea was a plan, and we were enthusiastic.

We did not conceive *Prelude* all at once: she grew slowly from a racing canoe to a 14-ft. dinghy, then in a wild moment to a 30 square-metre. But Sappers have always been ocean racers—it was inevitable that in the end we should go for a 25-ft. waterline (the minimum under R.O.R.C. rules), and a light, fast ocean cruiser. And as the boat grew in size, so the syndicate grew in numbers. With Brian Passmore and, later, Bill Purser, we were complete.

We began designing. The mess tent was littered with drawings, calculations, yachting books and plans of well-known yachts. Far into the night we bent strips of celluloid round pins, and faired in waterlines, sections, buttocks and diagonals. We made models, and looked at them before breakfast and on our return from schemes; gazed at them for minutes on end, or suddenly, as if to catch them unawares and find their weaknesses. We even essayed an enquiry into the theory of wave motion and streamlining, and not even the discovery that after three hours' work we had successfully integrated a sine curve twice and come back to the beginning really dismayed us. We paid a hurried visit to a well-known firm of yacht builders for advice, we wrote to Uffa Fox, we bought more and more celluloid —and in the end we decided that it was not worth the risk. If we were going to spend so much time and money on a boat, we must

at least give it a good start, we must go to the best designer we knew. We went to Laurent Giles.

Giles was enthusiastic. "If the Sappers can't build a ship, who can?" he said, and in a short half-hour he explained to us how it was done. A little bewildered, but with a feeling that now at last the die had been cast, we returned to Aldershot to look for a shipyard.

This was not easy to find. Every likely-looking shed, however disused it appeared to be from its outward appearance, turned out to fulfil some all-important military purpose. The building where the trumpeters practised would have suited us admirably: a deep-laid scheme to move them into our equitation store, the stores into another smaller store, and so on for several stages until at the end the groundsman moved his lawn-mower into an empty forage barn, broke down at the last moment because one person in the chain refused to co-operate. But we were fortunate in having the support of the Chief Engineer and the C.R.E.'s, and through their kindness we were eventually given the use of an old carpenters' workshop. This had a wooden floor and was situated on the bank of the Basingstoke Canal, which would no doubt give it the right atmosphere, but it had two disadvantages—a low roof and a small door. We should have to build our yacht first and put the lead keel and dead-wood on later; and as for getting the ship out, we should just have to knock down one of the walls of the shed and hope that the rest of it would not collapse in a heap as well. It was that sort of shed.

On the 8th November the lines plan and table of offsets arrived from Giles, and that afternoon we began drawing the sections full-size on the floor in chalk. This apparently was how one began, but somehow it did not work out quite as we had hoped. After two days our floor looked like nothing on earth—owing to a bad light, rough floor and no skill in the use of a chalk line. "What about my drawing-room?" suggested Millis, but Mrs. Jefferis had something to say about that, and in the end we bought some large sheets of three-ply wood and drew on them in pencil. This was a good idea, and we could now easily work to the required accuracy.

The next job was to make the moulds. We used 1" deal and knocked them up with 2½" nails turned over: screws would have been better. They had to be taken off the drawings, an allowance being made for the thickness of the planking as the drawings gave the outside dimensions of the hull. Knowing that the shape of our boat depended on these moulds, we spent endless time and trouble in making them accurate. Looking back on it now, in view of the ruthless way we altered the shape to please the eye later on, this may have been wasted time; but in those days, with the whole winter before us, our standards were high.

Moulds had to be made, too, for the various curved parts of the

backbone—stem, forward knee and sternpost. These we took off the profile (painted on the floor to prevent its being rubbed out), and rushed down to Moody's at Emsworth. Later, on what must surely have been the wettest, coldest day of the year, we collected the three enormous lumps of well-seasoned and suitably-grained oak, sawn out to the shape of our moulds, and brought them back to Aldershot in a car which was all too small for the job.

About that time Mr. Lewis arrived. From the first we had realized that the occasional help of a " real " shipwright, even if not essential, would save us so much time as to be well worth the expense. He would know all the tricks of the trade and, above all, he could do the adzing. We had read stories of adzes running amok in shipyards and ours had a nasty gleam about it. A few tentative strokes had convinced us that one must be born to use an adze, and we were not. We hid the thing away in a darkened corner and commissioned Brian to find us a man. He discovered Mr. Lewis in Rochester, and we were indeed fortunate, for such men must be rare. Lewis arrived carrying his adze nonchalantly over his shoulder and singing sea shanties, thereby inspiring our confidence and admiration from the very start. He stayed for five weeks, and came again for three weeks towards the end of the work.

Progress was rapid in those early days. It was a thrilling moment when we carried a great piece of oak into the shed and sawed it off the right length for the keel. This was the real thing: so far the work had all been preliminary, but this was to be part of the ship. Enthusiastically we began sawing it to shape—but long before we finished our enthusiasm had become grim determination, for the oak was good, and 4" thick. This was real work, and there was more to come; for the dead-wood below the keel had to be built up in layers of 6" Columbian pine. When at last it was all finished, we bolted the whole lot together and handed it over to Lewis to fair with his adze. Then we cut off the forward part to form the mould for our two-ton lead keel. Quite satisfied now that it would all fit together again, we took off the keel and laid it down in the centre of the shed.

Prelude has a keelson continuing the line of the stem and horn timber throughout the ship. Between this and the keel, every 1' 6" along, there are solid oak floors. Giles had given us a special table of offsets for these floors, so they were easy enough to cut out, but we had a great argument as to which way the grain should run. When finished, they were bolted to the keel.

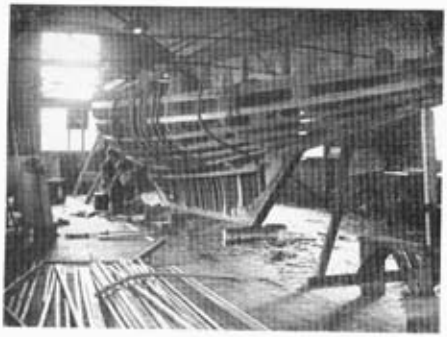
And now huge lorry-loads of timber were arriving from London, American rock-elm for the ribs, mahogany for the planking and Western red cedar for the deck. It usually came to the Guard Room, and was directed to " the shipyard down by the canal, just past the

THE BUILDING OF "PRELUDE."

All photographs taken by the Author.

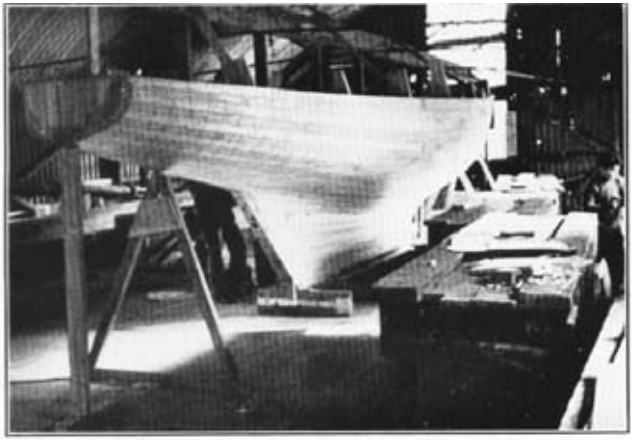
1.—(Nov., 1937.) The backbone set up. Note the deadwood and steamer in rear, and the oak floors.

2.—(Dec., 1937.) The moulds up and the beam shelves in position.

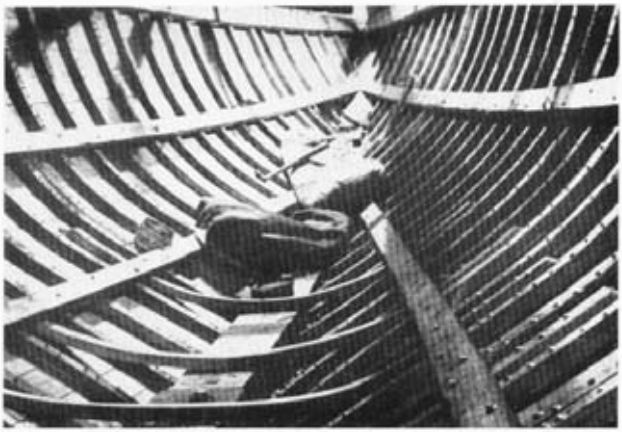


3.—(Dec., 1937.) The first few ribs.

The building of 'Prelude' 1, 2 & 3



4.—(Jan., 1938.) Planked up.



5.—(Feb., 1938.) The five thousandth odd rivet.

The building of 'Prelude' 4 & 5

stables." In the shipyard we would be working late, hunting clothes, football jerseys or running kit still on under our overalls. Millis would probably be in some impossible attitude on the floor, doing the job we had all left until to-morrow because we had no idea how to start it. Bill would be sharpening the chisels because, being a perfect craftsman, he never worked with blunt tools—I, on the contrary, always used the plane with great dents in it, so that when I hit a nail suddenly it didn't matter. But chiefly my memories are of looking in vain for one of our six set squares under the fast accumulating heap of shavings.

The various parts of the backbone were finished and bolted together in a huge 36′ curve of oak. Every 4′ along this a mould was set up and rigidly fastened to the ceiling. It all looked like the reconstruction of the skeleton of some huge prehistoric monster.

Now the two beam shelves had to be sprung into place. Notches were cut in the moulds to take them, and the fore ends were housed into the stem. Then, aided by ropes, tourniquets, clamps and levers, we bent the 4″ by 1½″ pitch pine and twisted it to give the tumble home. The wood creaked and groaned—it seemed that at any moment the thing would take charge and catapult itself or us through the walls of the shed—but in the end we won. The result immediately repaid us for our exertions. There is a moment in the construction of a ship when she ceases to be a collection of wood and becomes a ship. For me this happened quite suddenly as we sprung in the second beam shelf. From a strange museum piece, *Prelude* took shape and emerged a ship. We stood back and admired her form.

The stringers and temporary stringers followed the beam shelves, all laid longitudinally round the moulds, and then the steaming of the ribs began. We had made a steamer out of an old iron pipe and a boiler. The ribs were left in the steam about forty minutes, then coaxed into shape round the stringers and clamped on. We broke a great many at first, but with care and practice we persuaded them to take even the sharpest curves under the bilges. *Prelude* has all steamed ribs, 1″ by ¾″ at 6″ spacing, alternate ribs running across above the keelson and right down to the keel. As we worked, we faired each rib with its neighbour with battens.

Bill and I shamefully went off on leave, and at once longed to be back. Millis alone worked unceasingly, stopping only for a few hours to eat his Christmas dinner. The planking was going on now—¾″ mahogany ripped into 4″ tapering planks, planed to fit exactly and held to the ribs by copper rivets. We began at the bottom, obtained Lewis's aid for the difficult garboard strake, and worked upwards to the shelf. We caulked as we went, laying cotton along a pressed-in groove at the top of each plank. On the 23rd January the last plank was sprung on, and Bill brought the dismal news that at this stage

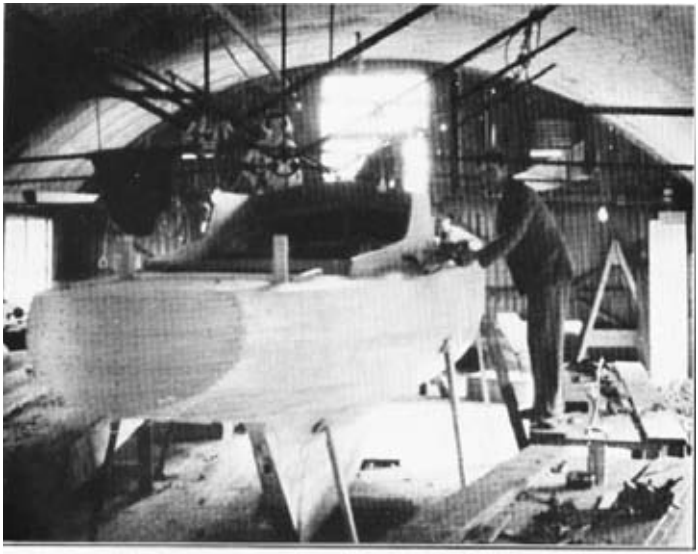
a yacht is only one-third finished. In our imagination this had been almost the end!

It took us three weeks to rivet up. There were six thousand rivets, and it was a tedious job. But knocking out the moulds and temporary stringers was real fun, while one by one the deck beams went in. And now we were thinking seriously about the accommodation. Giles had left this entirely to us, and naturally there were endless arguments and discussions. Over the major points we agreed—the galley well aft, a large oilskin locker, a quarter-bunk under the bridge deck, strong posts to catch hold of in rough weather, in all, simplicity and "keeping her open"—but the minor points were decided by compromise or by one of us stealing down at dead of night and cutting out the hole for the compass, or shaping irrevocably the teak for the cock-pit seat. In the end this method, or absence of method, worked well, for we are very pleased with our accommodation; and certainly a little decisive action at midnight made for speed. In contrast, we spent hours of time designing a ventilator which would let in air but no sea, and when it was finished Bill insisted upon trying it out with buckets of water. Bill is a good shot with a fire bucket, but (or perhaps, therefore) we all got very wet.

February came and went, while the deck was laid and covered with "Masonite." In the sunny days of March we were tempted to move *Prelude* out of the shed, but it was essential to finish every bit of painting first. We had many visitors now, and we reflected that if we had only thought of charging admission from the beginning we should have paid for our mast. At first we tried to make our visitors work, but we soon discovered that so much time was wasted explaining the job to them that the result was seldom worth it. All the same, a few friends came fairly regularly and gave us valuable help. Mrs. Jefferis, who, except for that early decision about her drawing-room, had helped enthusiastically all along, now became our interior decorator; while we planed, scraped and painted the outside. In April, our lead keel was cast in the Founders' Shop, and we fixed the launching date hopefully for the first of May.

Easter leave gave us a few clear days of work, and someone had left a neat pile of tubular scaffolding conveniently close by—excellent stuff for rollers and to make a Spanish windlass. On Easter Day, in the early morning, we gingerly allowed one tottering wall of our shed to fall down and rolled *Prelude* out into the sunlight. Then, improvizing two trestles of the Squadron Folding Boat Equipment, we lifted her up and lowered her on the keel and dead-wood. It was another memorable day.

During all this time Brian had been very busy. He had begun early on by making a dinghy, and then in a fit of exuberance another,



6.—(Mar., 1938.) Fitting the cabin top.

7.—(April 28th, 1938.) Ready to go down to the sea.

The building of 'Prelude' 6 & 7

8.—(April 30th, 1938.) The launching at Dell Quay.

The building of 'Prelude' 8 & 9

and yet another, in as many weeks. Slightly alarmed at this unexpected turn of events, we had implored him to stop building dinghies. This he did reluctantly and with a mild protest that he was becoming better at it every time and that his next one would have been a prince among dinghies. Since then, he had been our "London office," and whenever we wanted some more teak or another pot of paint we wired Brian. He was also O.C. rigging; and, in his masterly way, Brian had discovered a Home for old sailors, whose Principal found difficulty in keeping them amused, and they had eagerly agreed to do all our wire splicing. They had made a perfect job of it, and we heard later that the Home had taken on a new lease of life.

Our sails had been made by Gowan, of West Mersea, and our hollow mast by Stebbings, and both were now ready. At Aldershot we were making the cradle to take the ship down to the sea, while a hundred last-minute jobs were being completed. On April 29th *Prelude* was ready for the journey. We connected the cradle to the local contractor's lorry which we had hired, and waited for night.

It was a lovely night, clear and very still. We had supper late down in the shipyard—an excited supper of fish and chips—and at midnight we moved off, taking the road south through Farnham and Emsworth. There was a moment of anxiety at Emsworth Bridge: we had measured the clearance under the bridge beforehand, but two inches after removing the cabin hatch was a little less than we expected. At 3.30 a.m. we reached Dell Quay, the old port of Chichester; and soon after dawn, at dead low tide, we ran the cradle down the hard to the water's edge. Then we waited.

The sea came in and the water rose round *Prelude*. At 11 a.m. Mrs. Jefferis broke a bottle of champagne over the bows and our ship floated off—she did not turn turtle or heel over or sink: no, she floated fair and square. But we were too busy to admire; with our small outboard engine we motored her down to our moorings above Itchenor, and that afternoon we stepped the mast and fixed most of the standing rigging.

One week from that day—a week of absence back at work—we sailed. We beat down to the bar, and saw the Isle of Wight and the Nab; and in the evening we ran back to our moorings. It was six months to the day since we had drawn the first line in chalk on the floor, and the whole season was before us.

Now that first season is over. *Prelude* has sailed the Channel from Harwich to Falmouth, and twice been in French waters. She has stood up to rough weather and ghosted along in fine. She has raced, and won prizes, including the R.O.R.C. Points Cup for the season, and gained points for the R.E.Y.C. But, far more than this, she is our ship and we know her so well—every piece of timber, every joint

and every fastening. We know now that it was worth it, every time.

I have just seen *Prelude* again. It is a sad sight. She lies in her mud berth in Bill's back garden at Bosham, where we have laid her up for the winter. She has lost her mast and her rigging and her heavy teak rails, and the "Masonite" is being taken off her deck to be replaced with canvas. We have great ideas for improvements; and there is plenty of work for the winter.

We might even be able to see how that rusty spanner is getting on.

THE RHINE-MAIN-DANUBE CANAL.

Taken from an article in "Militärwissenschaftliche Mitteilungen" for January, 1939.

By MAJOR PROKOPH.

As long ago as A.D. 793 the Emperor Charlemagne attempted to establish a canal connection between the Danube and the Main, by the so-called "Fossa Carolina," of which portions remain to this day.

Nearly a thousand years later, new and very detailed plans of canals were prepared in France, providing connections between the Danube and the Oder, and between the Save and the Adriatic, respectively. The latter was to open up a cheap passage for Hungarian corn to Dalmatia and Italy. Owing to their high cost, neither of these projects materialized.

At the beginning of the nineteenth century the Vienna-Neustadt canal was built: it represented the first section of an artificial waterway from the Danube at Vienna to Trieste. It is now mostly in ruins. In 1836-46, King Ludwig I of Bavaria had the Ludwig canal built, which still connects the Danube with the Main. Its dimensions limit the traffic to ships of 100 tons: it does not, therefore, meet with the requirements of a main waterway.

All these canals have one point in common: the configuration of the country presents far greater engineering difficulties than canal works in the north German plains. If we follow the crest of the central European watershed, separating the Danubian basin from the rivers flowing into the North Sea and the Baltic, we find that the lowest saddles are 300 to 500 metres above sea level, whereas the Rhine at Mainz is only 82 m., the Elbe at Aussig only 137 m., and the Oder at Breslau only 116 m. above sea level.

Recently, a Frankfurt shipping concern has organized a system of motor-boat transport from the Rhine to the Danube, utilizing the Ludwig Canal. The service will be maintained by means of small ships of about 100 tons capacity: it will, consequently, not develop into a very important business.

The announcement was made a short time ago that the Rhine-Main-Danube Canal, for large ships, will now be begun. It will be of different design, and of larger dimensions than anything previously built, and will have a system of locks; but, on the whole, it will follow the approximate alignment of the Ludwig Canal.

The width of the canal at water level will be 38 m. (128 ft.). This will enable two large tows of barges to pass one another. The depth of water will be 3·75 m., thus allowing the passage of 1,500 ton ships.

The new canal leaves the Rhine at Mainz, and follows the Main upstream, touching Frankfurt, Offenbach, Aschaffenburg, Würzburg, and Bamberg. From this point it follows the Ludwig Canal, passing Nürnberg, and dropping, below Beilngries, into the Altmühl river, which, not many miles farther, joins the Danube at Kelheim, some 40 km. upstream of Regensburg (Ratisbon).

Work has been going on for some time on the canalization of the Main. In 1921, the government of the Reich, in taking over charge of waterways, undertook to establish a canal connection, from Bamberg, via Nürnberg to Kelheim. But, owing to unsatisfactory economic conditions during the first few years after the war, no progress was made with this project.

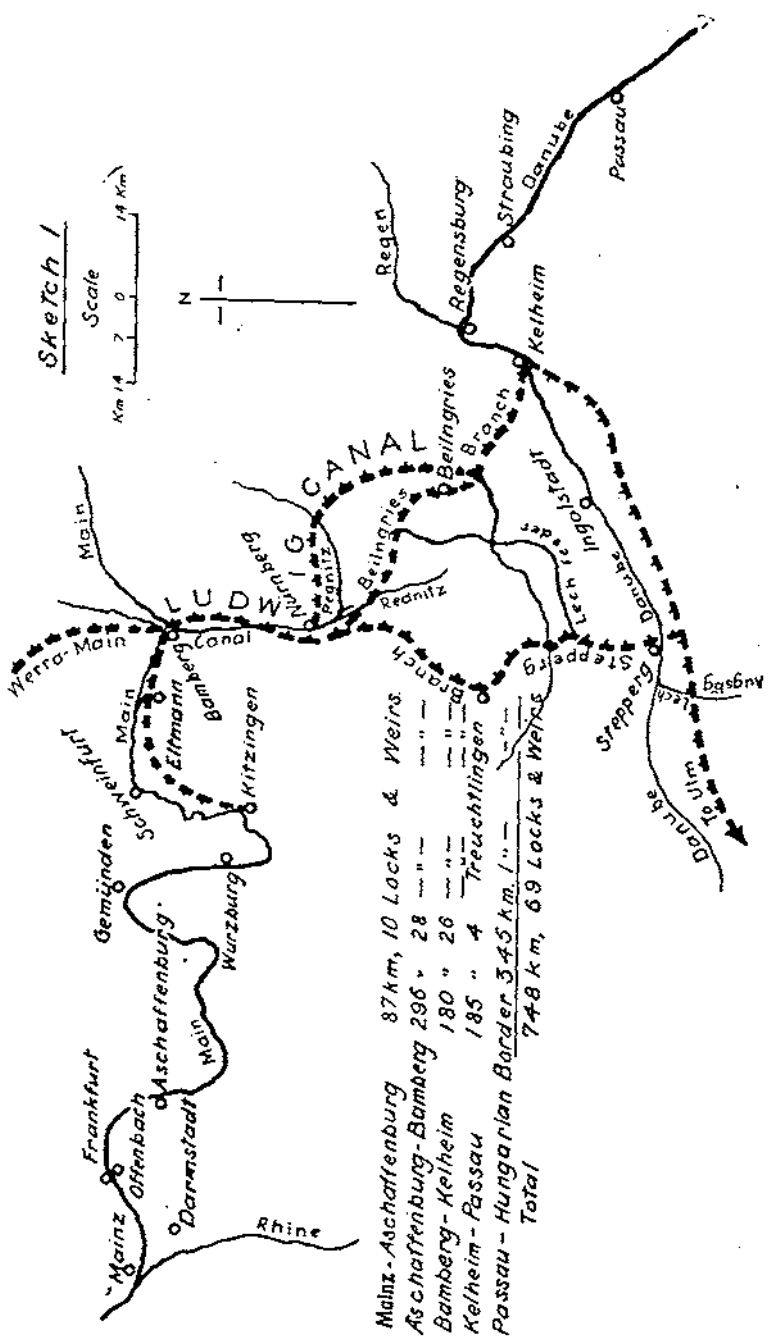
In his speech on March 26th, 1938, Field-Marshal Göring indicated the early completion of the Rhine-Main-Danube Canal as one of the most important tasks for establishing commercial relations with Austria. The canal, which will be open to large vessels as far as the German-Hungarian boundary, forms part of the four-year plan. The date of completion has been fixed for 1945.

The canalization of the Main will have reached Würzburg in the autumn of 1938, and Nürnberg in 1943. By that time, 250 km. upstream of Mainz will be ready for 1,500 ton ships. At the same time, canalization will be proceeding between Würzburg and Bamberg.

The building programme visualizes spreading the work on the stretches from Würzburg to Bamberg and from Beilngries to Regensburg over seven years. From the beginning of 1939 work will be begun simultaneously in several places between Bamberg and Beilngries.

Sketch 1 shows the proposal to divide the Ludwig Canal into two branches: one running from Nürnberg, along the line already described, past Beilngries (the Beilngries branch) to Kelheim; the other taking off it a short way south of Nürnberg, keeping to the west of the first, and meeting the Danube at Stepperg (the Stepperg branch). Both canals are connected with the Lech feeder. The Stepperg branch gives Augsburg, Ulm and Munich, which are all a long way from Beilngries, a shorter connection with the Rhine-Main-Danube Canal: but it is probable that the two branches will eventually be connected together south of the Danube.

The Fossa Carolina—mentioned earlier—started from Bamberg, passed through Nürnberg, and ended at Treuchtlingen, a place that lies on the proposed alignment of the western branch of the Ludwig Canal. It did not reach the Danube. On the other hand, the eastern branch of the Ludwig Canal was only partly navigable.


Sketch 1
Scale
Km 14 7 0 14 Km
N
Rhine
Mainz
Frankfurt
Offenbach
Darmstadt
Aschaffenburg
Main
Würzburg
Kitzingen
Gemünden
Schweinfurt
Main
Ellmann
Bamberg
Canal
Werra-Main
Main
LUDWIG CANAL
Nürnberg
Pegnitz
Regnitz
Beilngries
Beilngries
Branch
Regen
Regensburg
Straubing
Danube
Passau
Kelheim
Ingolstadt
Lech
Danube
Stepperg
Stepperg
Branch
Augsburg
Lech
Donau
Ulm
Mainz - Aschaffenburg 87 km, 10 Locks & Weirs
Aschaffenburg - Bamberg 296 " 28 " " " " "
Bamberg - Kelheim 180 " 26 " " " " "
Kelheim - Passau 185 " 4 Treuchtlingen " " "
Passau - Hungarian Border 345 km. / " "
Total 748 km, 69 Locks & Weirs

It is also proposed to utilize the water power available in the upper Danube between Ulm and Kelheim, and, at the same time, to make this portion of the river navigable for large ships. This scheme is important for the industrial development of the sparsely inhabited valley of the upper Danube.

The conversion of the stretch of the Danube between Regensburg and Passau into a highway for large ships was completed ten years ago by the construction of a dam in the rocky gorge of the Kachlet above Passau. This dam also serves as a source of electric power. In the Ostmark (Austria) some major works will be necessary in the Aschach Kachlet (upstream of Linz), which, from the point of view of navigation, is the most difficult section. Here the current in the Danube is dangerously swift. The bed of the river often has pools 50 feet deep, alongside of rocky shallows 7 to 8 feet deep, leaving a narrow passage in which navigation is only possible in one direction. By the construction of a hydro-electric power station at Ybbs-Persenbeug, in which a dam is combined with a lock, it will be possible to work traffic both ways, besides providing electrical energy. The water will be ponded up for 20 to 30 km., as far as the Grein district.

Altogether, there are to be constructed on the Rhine-Main-Danube Canal :—

43 large locks
22 weirs on the Main, Altmühl and Danube
170 major bridges
6 large emergency escapes.

This gives an idea of the magnitude of the scheme, which is estimated to cost 600 million R.M. (£54,000,000). The funds have been arranged for : eleven-twelfths of the cost will be borne by the Reich, the balance by Bavaria.

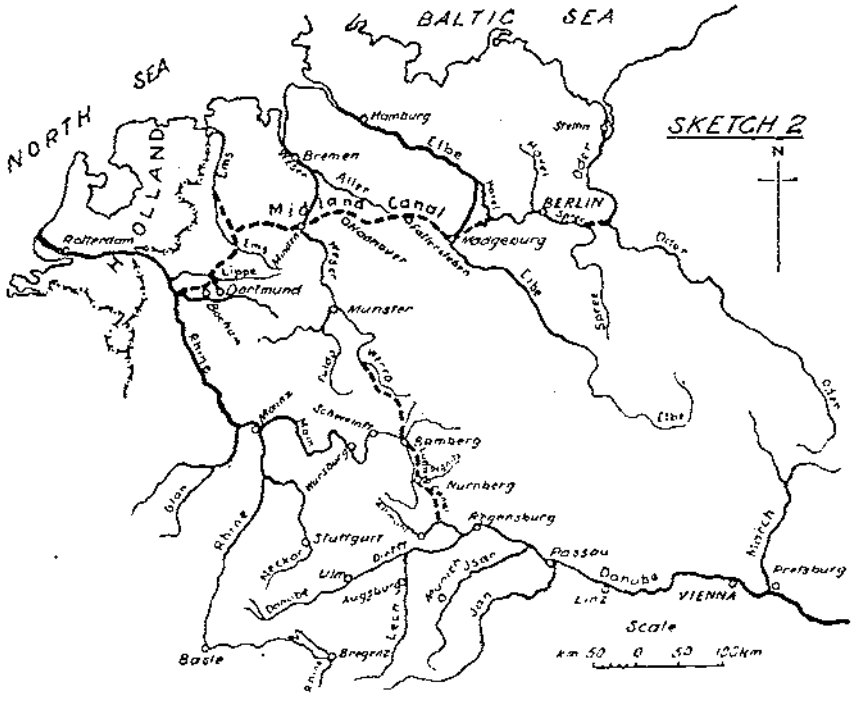
Working upwards from the Rhine, the canal has to overcome a height of 330 metres. A small portion of this is taken up by the ordinary gradient, by far the greater part by the locks detailed on sketch 1. From Mainz to Kelheim the total length amounts to 563 km. Of this, 250 km. have been completed.

There are several other projects in Germany for great waterways, that have been partially put in hand. They will not be squeezed out by the construction of the Rhine-Main-Danube Canal, but will be carried out simultaneously.

These plans are mentioned here because they will only perform their full function when taken in conjunction with the Rhine-Main-Danube Canal. Similarly, the latter canal can only serve its full purpose in combination with an extensive network of waterways in the north.

The most important projected waterway is the Werra-Main Canal, which connects Bamberg on the Main, via the Werra and the

Weser, with Bremen. Such a waterway, leading to a German harbour, is of special value, because it is Germany's policy to direct export trade to German ports. The Rhine will increase in importance by the construction of the Rhine-Main-Danube Canal, but, in its lower reaches, it passes through Dutch territory, and discharges into the North Sea at Rotterdam. The cost of handling and trans-shipment at foreign ports involves a heavy outlay, which is saved when goods are directed to a German port. For this reason work is proceeding with equal energy on the Werra-Main Canal as on the Rhine-Main-Danube Canal.



The canalization of the upper Werra was begun in November, 1937. Since there are now still 135 km. to be constructed, it should be completed at the same time as the Rhine-Main-Danube Canal.

Bamberg, at the junction of the Rhine-Main-Danube Canal and the Werra-Main Canal, is likely to develop into an important port.

There are a number of other canals, some partly built, some projected, giving connection between the Danube and the German waterway system. The old project for connecting the Danube with the Oder has been revived and will shortly be taken in hand.

The Midland Canal was completed in the autumn of 1938. It connects the Oder with the Spree, crosses half Germany from east to west, via Magdeburg and Hanover, until it reaches the Ruhr district and the Rhine. Eventually, the great sea ports of Bremen,

Hamburg and Stettin will all be connected with the inland canal system.

Germany's mineral wealth is, to a great extent, derived from mining districts near her frontiers: her canal system will now ensure a cheap and reliable distribution of raw materials to all parts of the country.

The falls in the canals will serve as sources of electric power. There will be forty such falls in the Rhine-Main-Danube Canal, developing enough power to meet the whole requirements of Bavaria.

Preliminary work, from 1933 onwards, has absorbed large quantities of labour without disturbing the labour market. When work on the Rhine-Main-Danube Canal is in full swing, however, and the "Autobahnen" programme is being carried out at the same time, it will probably be necessary to import Italian labour.

Germany obtains about 20 per cent of her requirements of crude oil and petrol, either in the shape of shale oil, or by the liquefaction of coal. The balance is largely obtained from Rumania. Fleets of tankers are engaged in carrying oil up the Danube.

The lower Danubian countries find difficulty in exporting the surplus of their agricultural produce. Rumania and Bulgaria grow large quantities of the soya bean, a particularly valuable product for the German people, who suffered greatly during the war from deficiency of oils and fats.

It is a mistake to suppose that the canal system will provide a cheaper connection between the Black Sea and the North Sea than the all-sea route. The reverse will always be the case. Ice invariably blocks traffic in the winter, and in the autumn the depth of water in the Danube is often only two metres. A 1,200-ton ship has a draught of 2·5 metres. The ships now plying on the Danube are limited to 760 tons.

There are difficulties connected with the silting up of the three branches of the Danubian delta. The construction of the Rhine-Main-Danube Canal has led Rumania to revive the project of the Dobruja Canal (from Cernavoda on the Danube to Constanza on the Black Sea), estimated to cost 120 million R.M. (£11,000,000). The canal should be completed in four years' time.

Vienna will shortly become an important port, capable of accommodating 400 ships.

The total cost of the German waterway system is estimated at 1,600 million R.M. (£145,000,000). It is hoped to liquidate this debt within a few decades. The canals are expected to reduce freights all over the country, without harmful competition with the railways. When the canals have been completed—in ten or twelve years' time—Greater Germany will have, in addition to her railways and "Autobahnen," the densest and most complete traffic system in the world.

THE MERSEY AND IRWELL BASIN.

Its History and Control.

By Stanley Pearson, M.Inst.C.E., M.Inst.W.E., F.R.G.S.
Late Major R.E., S.R.

(*Chief Engineer, Rivers Mersey and Irwell Catchment Board.*

To the average man, and even to the civil engineer whose activities seldom bring him into contact with rivers, the terms land drainage or river engineering may imply little, so I venture to present a brief sketch of one of the river systems in this country, in the hope that some of the information contained therein may prove of interest.

The upper Mersey and Irwell Basin is composed of parts of the West Riding of Yorkshire, Derbyshire, Cheshire and Lancashire, and includes the most densely populated industrial area of the British Isles, whose industries are dependent on these rivers for power, cooling and process water.

Study of Rivers.

Now the study of rivers is in itself one of the most interesting of subjects in that, like most things, when one comes to go into the why and the wherefore, there is far more in them than meets the eye.

Their origin, for instance, is generally far more complex than one would at first suppose, being so largely affected by geological changes. For example, there is strong evidence to indicate that the Thames was, at one time, a tributary of the Rhine, and that the Mersey, in the pre-glacial epoch, did not discharge by its present mouth at Liverpool, but by the estuary of the Dee. In fact, a great variety of processes have generally been responsible for a river's formation, each leaving some mark on its scenery or relief.

Geological History.

To take the local examples of the Mersey and Irwell and to cut a long story short, we have evidence that the following stages have gone to make up this life history :—

1. Deposit of sediment in a clear sea abounding in marine life. (Carboniferous era.)

2. Upheaval and formation of great swamps supporting abundant vegetation in a tropical climate. (Coal measures.)
3. Great earth crust movements evolving mountain ranges. (Tertiary period.)
4. Denudation of these under desert conditions. (Sandstone era.)
5. Ice Age, or Glacial Epoch, damming up great lakes, and leaving behind sand and boulders.

There is, for instance, evidence that the drainage of a very extensive lake or lakes on the north side of the Forest of Rossendale escaped south through the Rivington Gap, near Chorley, into the basin of the Irwell. Some of these overflow channels can be readily identified at the present time, and at one time it is clear that the whole drainage of east and south-west Lancashire must have flowed south along the slopes of the Pennines, east of Stockport.

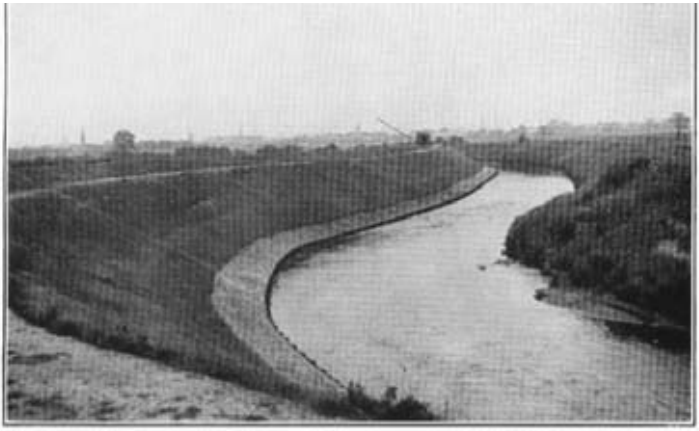
As the ice retreated towards the north with the change of climate, the rivers began their careers on the surface of the glacial drift.

It was thus that the Mersey began its westerly course over the glacial deposits which concealed its former channel. In support of this, it has been proved that at Runcorn the old channel of the Mersey is buried under glacial drift and lies to one side of the present channel, and in the case of the Irwell its course was greatly altered at a later stage in the Glacial Epoch. For instance, above Radcliffe, the river flows in a wide, flat-floored valley of ancient origin, but for three miles below that place it runs along the bottom of a deep and narrow winding ravine (Nob End ?), which cuts through the Coal Measures of much more recent origin. It can, therefore, be assumed that the previous channel of the Irwell, downstream of Radcliffe, is now buried beneath glacial drift, possibly somewhere near Whitefield and Prestwich, where the drift is known to be of great thickness, as has been proved by colliery workings.

MOVEMENT OF CHANNELS.

Such changes as these are, of course, the result of millions of years of geological history, but it must not be thought that river channels to-day are stabilized. Considerable movement and shifting of channels is always going on, and is apparent if careful survey and observations are made. The Mersey, for instance, has, in one place, broken through a bend and shifted its course by some hundreds of feet in the last three years.

This is rather an extreme case, and largely due to interference with the natural conditions by the construction of the Manchester



1.—Toe revetment and flood bank.

2.—River Mersey. Showing completed piling (steel and timber) and bank toe revetment.

The Mersey & Irwell basin 1 & 2

3.—River Mersey. Driving interlocking sheet steel piling.

4.—Toe revetment.

The Mersey & Irwell basin 3 & 4.

Ship Canal; for it can be taken as an axiom that, if one interferes with nature, she generally strikes back, but does not always conform to Queensberry rules.

Regime of Rivers.

Rivers are said to have a regime, and the best analogy of this is "character."

Innumerable factors are combined to form this "character," and it must be remembered that each factor varies in different parts of the river.

Hard and fast rules will not give results in the study of rivers, for the regime of a river, like a human character, cannot be said to have a duplicate; it may resemble another in 99 points out of 100, but that one point is enough to throw out all previous calculations.

In fact, it may be said that rivers are distinctly complex, or shall we say feminine in character, in that one never knows what they are going to do next, and each is a life study in itself.

Collection of Data.

It is very necessary indeed to know something of the vagaries and habits of a river before attempting to design flood protection and stabilization works, which are, generally, extremely costly. It is necessary, for instance, to know such things as discharges and velocities, both at dry weather flow and maximum flood, and it will be appreciated that reliable data can only be obtained over a period of years, in which we have to take the dry with the wet years.

In the case of the Mersey and Irwell, very little reliable hydrographical information exists from the past, and it has been necessary to start in from zero and install gauges recording continuously, day and night, the heights and discharges of the rivers, and thus establish a series of records from which such major works as cuts, weirs, by-passes, floodbanks and bank protection works can be designed.

It has, of course, in some cases, been necessary, on account of urgency, to rush through protective works, and in such cases one would have to decide from experience, and what data could be obtained, the kind of works that would meet the case.

Tributaries.

The Mersey and Irwell have, of course, a number of tributaries, of which the principal, without subdividing down into the smaller brooks, are as follows:—

MERSEY	Goyt Etherow Tame Lady and Mickerbrook
IRWELL	Roch Beal Bradshaw Tonge Croal Eagley Irk Medlock

FORMATION OF THE UPPER MERSEY.

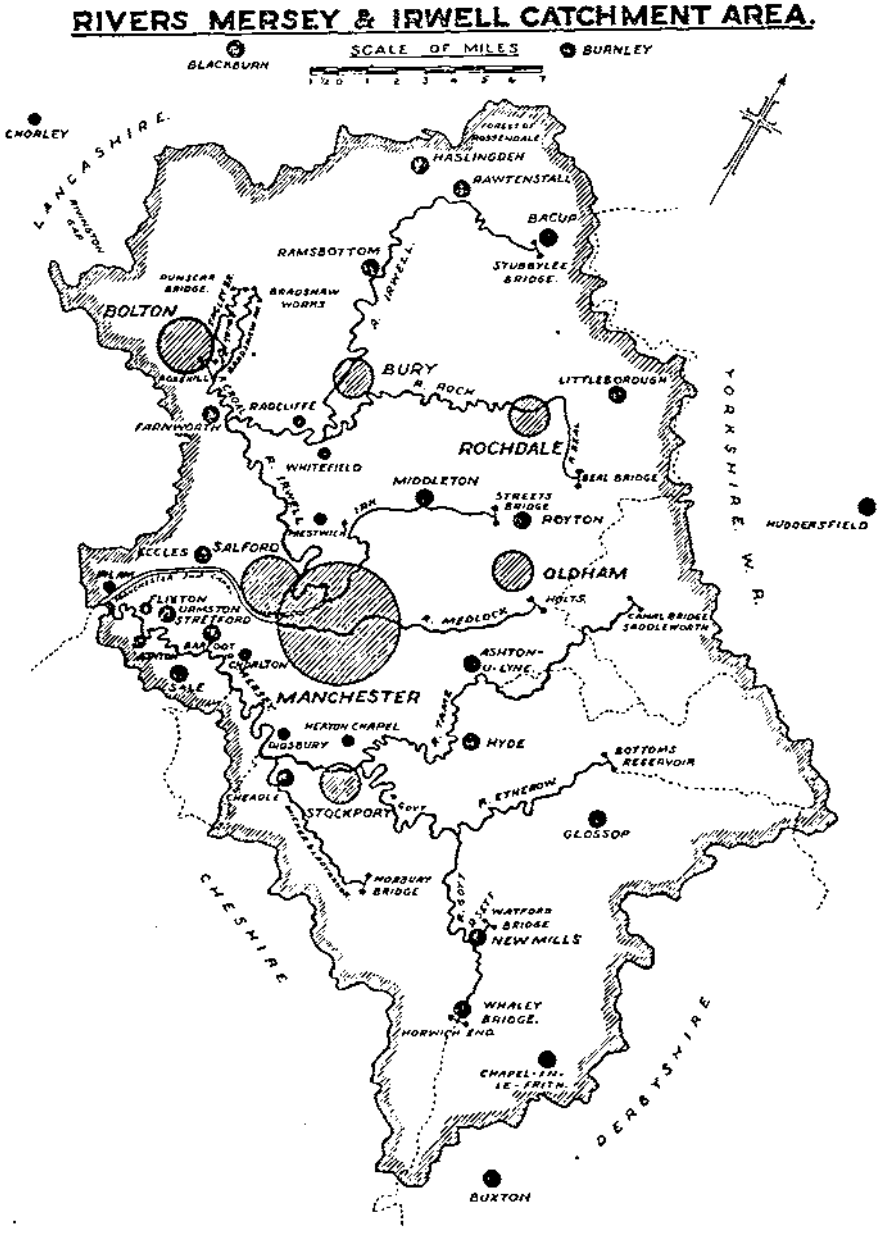
Let us now, for a moment, take in more detail the case of what I will call the Upper Mersey. (By this I mean the Mersey above its point of discharge into the Manchester Ship Canal at Irlam Weir.)

To form this upper Mersey, we have three rivers, viz., the Goyt, the Etherow and the Tame, rising high up in the Pennine chain and Derbyshire hills, starting as torrential streams, changing at lower altitudes into what we will call swift-running streams, until they unite above Stockport to form the slower-running Mersey proper, which, at Heaton Chapel, enters what I will call the Manchester Plain, *i.e.*, the broad, flat valley which the river has itself formed during centuries of time by having pursued a meandering course across the valley, and, in times of flood, spreading out and depositing sand and mud ; the area thus liable to flood being known as " Ees " (or water meadows).

There is ample evidence of this meandering in the river terraces or platforms left standing several feet above the valley plain, and separated from it by a steep bank or slope. These platforms or river terraces, as they are geologically called, were made at a time when the Mersey flowed at a higher level than at present, the river having now cut its bed deeper and left the terraces standing.

In places, these platforms stand 6 to 8 feet above the alluvial plain, and in others they may be as much as 25 to 30 feet above its level.

Careful examination reveals the existence of remnants of three distinct terraces. The most extensive of these ancient alluvial plains is that which occurs on both sides of the river below Stockport, and most of the southern suburbs of Manchester, such as Didsbury, Chorlton, Flixton, Urmston and Stretford lie on it. There are also traces of lower terraces.


RIVERS MERSEY & IRWELL CATCHMENT AREA.
SCALE OF MILES
BLACKBURN
BURNLEY
CHORLEY
LANCASHIRE
HASLINGDEN
RAWTENSTALL
BACUP
RAMSBOTTOM
STUBBYLEE BRIDGE
R. IRWELL
BOLTON
BRADSHAW WORKS
BURY
R. ROCH
LITTLEBOROUGH
RADCLIFFE
FARNWORTH
ROCHDALE
WHITEFIELD
MIDDLETON
STREETS BRIDGE
ROYTON
HUDDERSFIELD
YORKSHIRE W. R.
SALFORD
ECCLES
OLDHAM
HOLTS
R. MEDLOCK
ASHTON-U.-LYNE
MANCHESTER
SALE
HEATON CHAPEL
DIGBURY
HYDE
BOTTOMS RESERVOIR
R. ETHEROW
STOCKPORT
GLOSSOP
CHESHIRE
MORLEY BRIDGE
WATFORD BRIDGE
NEW MILLS
WHALEY BRIDGE
CHAPEL-EN-LE-FRITH
DERBYSHIRE
BUXTON

CONSTRUCTION OF FLOODBANKS.

To check this flooding tendency, floodbanks or levees, as I shall call them hereafter, were, in the past, constructed above the level of the surrounding land, so that an additional height of river bank was provided, thus allowing the river, at flood time, to flow at a higher level than the adjacent land.

So far as can be traced, these levees were reconstructed at the end of the eighteenth century, by the landowners themselves, but, since there was no controlling authority, each landowner constructed what he thought was necessary for his own requirements, without looking at the river as a whole, with the result that, in many cases, the levees were made too weak or too low, and, in consequence, breaching and flooding were of common occurrence.

Two main factors were not taken into account when these levees were constructed, viz. :—

1. The large increase in building and roads that has now taken place, which, by waterproofing the land surface, increases and speeds up the run-off from such areas, thus increasing the discharge into the river at a given time, because the rain-water has no chance of percolating through the soil.
2. The construction of the Ship Canal, which has entirely changed the regime of this part of the river, seeing that, at Irlam, it cuts through the old Mersey Channel, giving the water a free outfall at this point, and thereby lowering the flood level by some 14 feet.

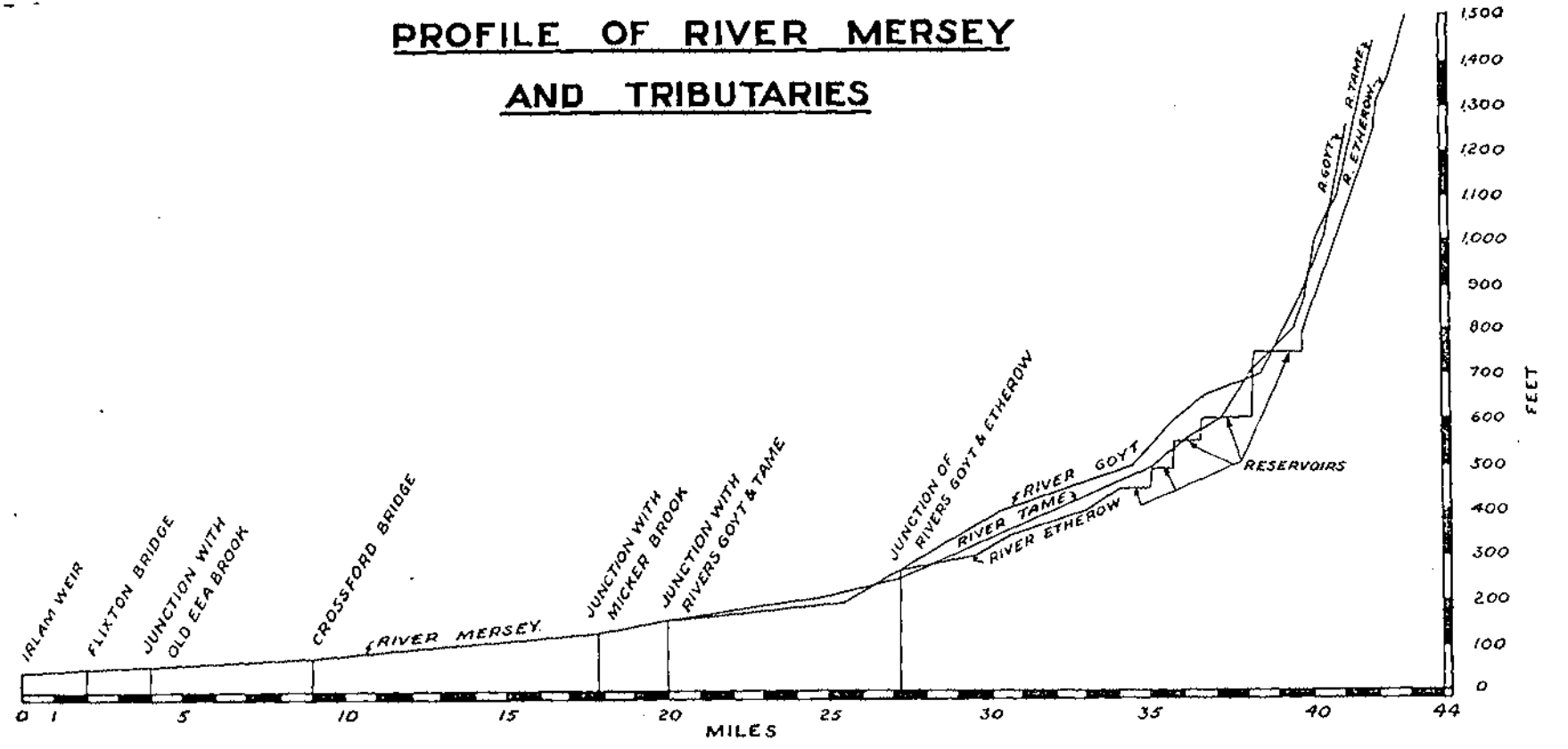
This lowering of the flood level at Irlam means an increased inclination of the water surface at flood time, and, consequently, an increased velocity ; with the result that the river banks, which are, for the most part, in soft, sandy, alluvial soil, are unable to withstand this velocity, and have, in consequence, eroded, causing the levees, which were constructed too close to the top edge of the natural river banks, to fall into the river, and thus the protection against flooding, in many places, no longer exists.

To protect the natural river banks against this velocity, which reaches some 7 feet per second, and more, and provide new levees is, to-day, proving a costly matter.

USE OF RIVERS.

Another point which we have to remember about our local rivers is that they are acknowledged to be the hardest worked in the world. Their waters, almost as soon as they emerge from their sources, are pounced upon and made use of by the countless mills,

PROFILE OF RIVER MERSEY AND TRIBUTARIES



dyeing, bleaching, chemical and other works situated in profusion along the river banks.

In order to obtain such water and divert it into intakes, hundreds of weirs have been constructed, which themselves constitute a hindrance to the getting away of flood waters, more especially in the lower reaches.

The rapidity with which such flood waters rise must be seen to be appreciated, for in the upper portions of the catchment area, where the rainfall is heaviest (over 50 inches per annum against 30 inches in the lower reaches), we get an exceedingly rapid run-off down the steep-sided Pennines, culminating in what is virtually a flood-wave or bore.

In the case of the Mersey, a rise of over 16 feet in between 3 and 4 hours has been several times recorded.

In other words, the Mersey can be classed as a flash, or somewhat hysterical river, and, having been allowed to get thoroughly out of hand, is now being gradually brought under control.

MAINTENANCE AND IMPROVEMENT OF BANKS.

Besides the construction of levees, which, of course, need to be properly designed according to the depth of water which they will have to withstand, and the nature of the material employed, we have to provide for adequate protection of the toe of the river bank, and the lower slopes of the bank against the wash of the current. Corners have to be eased and rounded off and protected against erosion and bridge openings streamlined to enable them to pass more water in a given time, for it can generally be taken as an axiom that the last consideration of the earlier bridge designers was the question of waterway, with the result that a great number of bridges give a waterway that is quite inadequate. The river channel has also to be opened out, or, in some cases, contracted, to keep the correct velocity to avoid either erosion or silting, and the river bed cleaned, dredged and graded.

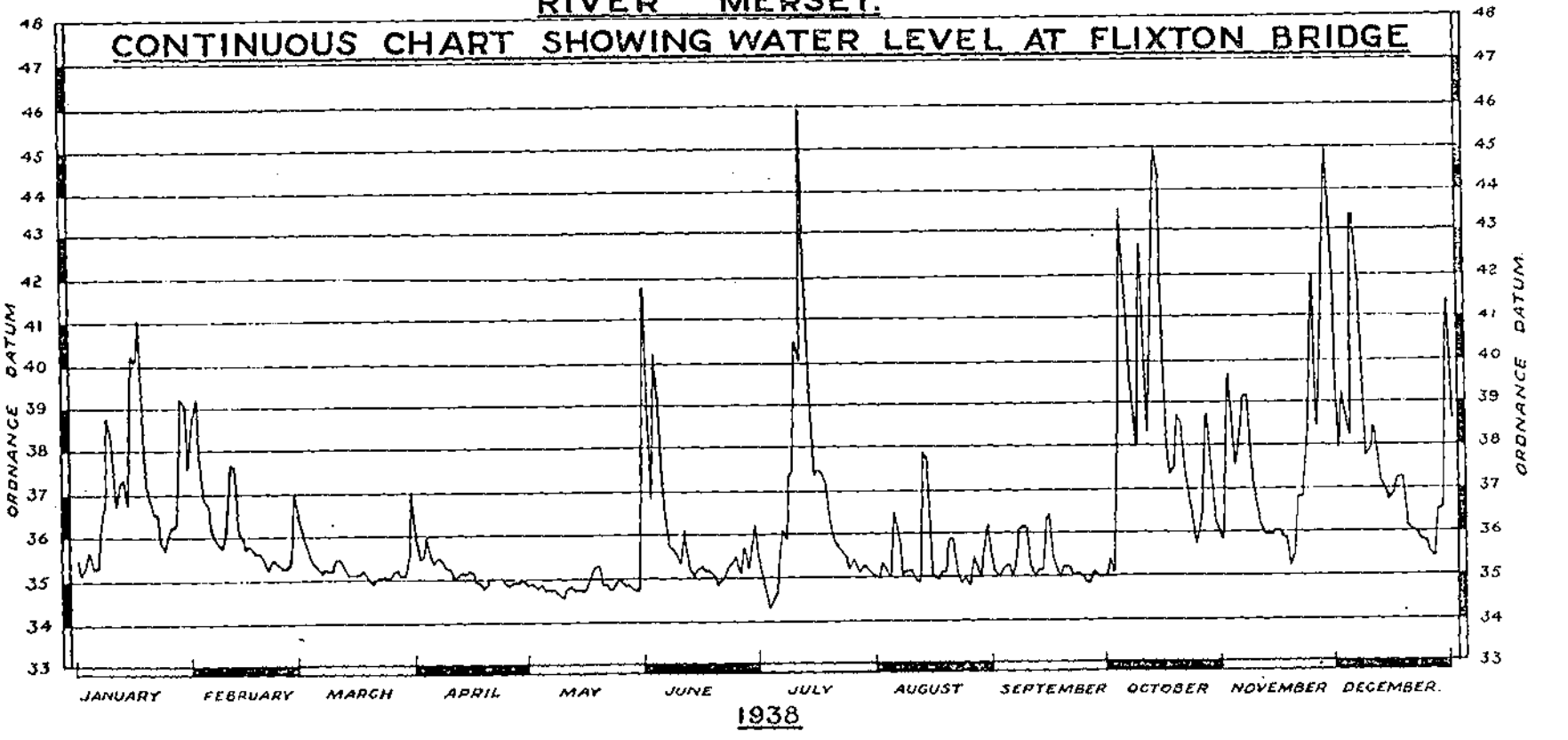
In addition to the above, cuts and by-passes to shorten the winding channel have to be considered and designed, and these, on account of the alteration in the bed gradient, and hence increased velocity, generally call for the insertion of weirs to check such increase of velocity.

The works that have been carried out so far have had for their object the prevention of flooding and the getting away of the water to the sea by means of :—

1. The opening out of the waterway to give the necessary cross-sectional area.

RIVER MERSEY.

CONTINUOUS CHART SHOWING WATER LEVEL AT FLIXTON BRIDGE



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2. The construction of levees set well back from the bank edge, see Figures 1 and 2, thus giving the river a flood channel into which it can expand.
3. The stabilizing of the banks by means of a revetted and piled toe, pitched and turfed slopes.

A certain proportion of these works have been carried out by contract and the remainder, where it has been difficult to specify, by direct labour under the supervision of the Board's Engineering Staff. The design of the works is based on a channel to provide, in the case of the Mersey, a maximum flood discharge of 10,000 cusecs and for the Irwell, 18,500 cusecs, although the catastrophic flood of November 16th, 1866, was estimated for the Mersey at 14,000 cusecs and for the Irwell at 28,000 cusecs; but to design work for a catastrophic flood that may come only once in 100 years is not necessarily an economic proposition, as the capital outlay may far outweigh the possible damage. Velocities at peak flood may rise to over 8 feet per second but this, it must be remembered, is generally of short duration and a mean velocity of 4 to 5 feet per second is generally aimed at. Owing to the great length of river that has to be dealt with, much of it urgently, most of the toe revetment has been carried out with pitch pine piling and walings, see Fig. 2, but when built-up areas or public works such as sewage works abut on to the river, or at specially abrupt bends, interlocking steel sheet piling and concrete are used. Dragline excavators are employed in connection with Jubilee track and petrol or diesel locomotives and, in some cases, Muirhill dumpers. The general slopes of levees and banks are 2 and 2½ to 1, depending on the nature of the material available, and it is found that, by using a toothless bucket with the dragline, a firm batter can be cut which needs practically no hand trimming; the photos and sketches, Figs. 1 and 2, show the type of construction employed. The piles used vary in length from 15 to 26 feet and in section from Larssen No. 2 to Larssen OGB, though very little of the latter has been used on the main river. The timber pile sections vary from 6 by 6 inches to 12 by 12 inches and walings average 3 inches in thickness. Pile-driving is carried out by McKiernan Terry or Johnson hammers and by false leaders and monkey attached to the dragline.

An anti-scour rubble toe is hand-packed on the river side of the walings and rubble back-filling compactly filled in behind same. Uncoursed random stone paving 6 inches thick and dry jointed is provided to a height of 3 to 4 feet above the top of the piles and dished to a radius of 12 feet, the width of the paving being 6 to 9 feet. It is found that this type of paving does not become dislodged and accommodates itself to small settlements, and the interstices quickly become sealed with river silt. Most of the stone used is of

TYPICAL CROSS SECTIONS OF RIVER MERSEY AT ASHTON (STEEL PILING)

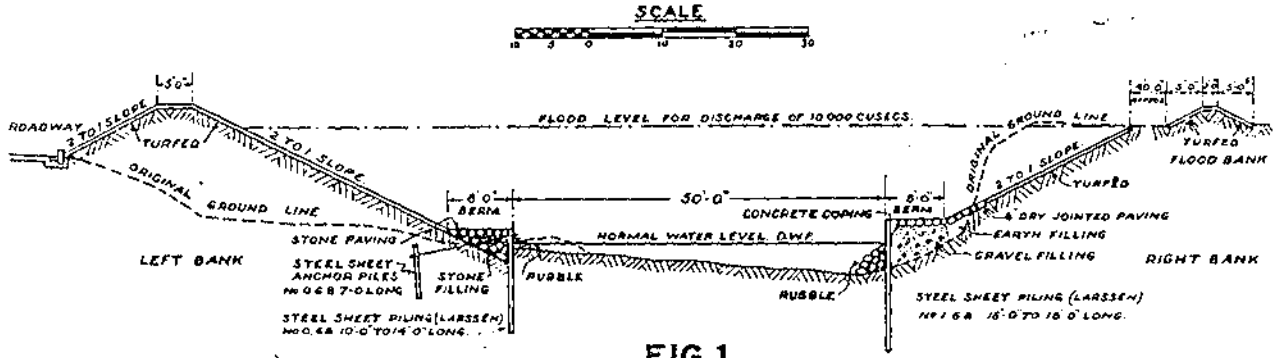


FIG. 1.

TYPICAL CROSS SECTIONS OF RIVER MERSEY AT BARFOOT (TIMBER PILING)

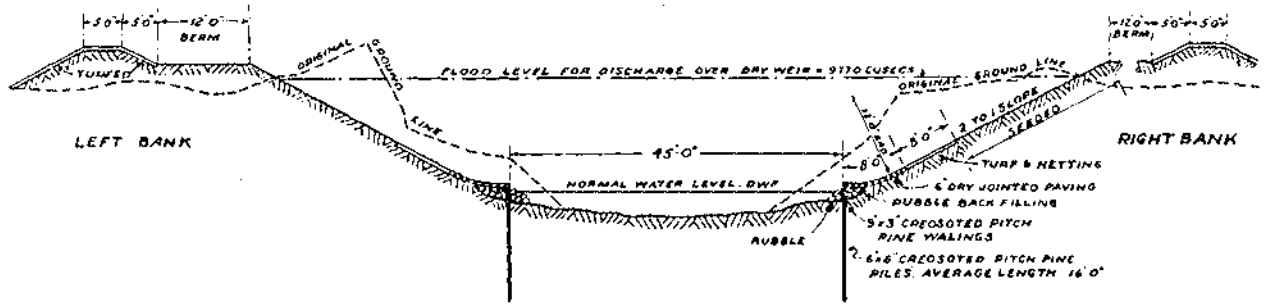


FIG. 2.

the freestone variety, which is both durable and easy to work. Above the stone paving, over a width (or depth) of 8 feet, turf stripped from the site is laid and kept in place with wire netting and galvanized iron skewers until it has knitted. The slopes above this and the back slopes of the levees are seeded, the front slopes being turfed in the manner referred to above. Some ten miles of river bank have already been treated in this way and have, so far, stood up to all floods.

It would, I consider, be inappropriate to end without stressing the river gauging and hydrographical surveys. These have been in progress since the Board's inception and are of the utmost importance, since they must provide the data on which major works are designed. Gauging stations, with automatic flow and level recorders giving continuous readings, have been established in all main rivers, and the weirs in connection with them calibrated by means of model experiments. In addition, current meter observations, at different stages or heights of the river have been made and stage discharge curves computed.

The records so obtained in conjunction with concurrent rainfall observations should prove invaluable. Another matter, viz., the question of period of concentration or time of arrival of flood waters from the uplands is also of the greatest importance, since, if the flood water from the main tributaries synchronize and arrive together at the main river, flooding is inevitable, whereas, if one flood-wave lags behind the other, we may get all the water away without flooding.

I think from what has been said it will be seen that the work of a Catchment Board Engineer is both interesting and varied. Besides having to be an expert in river engineering and hydraulics, he needs to have a sound knowledge of canal, railway, highway, bridge, sewage and municipal engineering, since he will be dealing with all these branches, has to hold his own with their engineers and at times criticize their designs, as also the heads of vested interests, dependent on the river for their various processes. He is continually pitting his knowledge and wits against Nature and not always in her gentlest moods. He has to use his judgment as to when to humour and when to try and master these moods but must never relax their study, be it of the past, present or future.

THE APPLICATION OF SOIL MECHANICS TO ROAD CONSTRUCTION AND THE USE OF BITUMEN EMULSION FOR STABILIZATION OF SOILS.

A Lecture delivered at the S.M.E., Chatham, on January, 19th 1939.

By BRIGADIER C. H. HASWELL, C.I.E.

BEFORE getting on to my subject, it may be of interest to tell you how stabilization of soil has got to its present stage, and why the intensive research started in 1933.

During the Khajuri Plain Operations near Peshawar in 1930–31, the job of the R.E. was to make a road across the Khajuri Plain. With all the resources of field companies, S. & M., M.E.S. and P.W.D., the most that could be accomplished was a quarter of a mile per day.

The Railway Department could construct one mile a day, and therefore something new in the way of quick road construction had to be found out.

In 1931 I moved across to the Western Command, and there I found miles of old water-bound macadam roads, which had been let go, owing to financial stringency, and which had been covered with 3 inches of loose gravel to make them passable. This was hard on cars and tyres, and on curves was a danger and the cause of many accidents. There was also a very large mileage of earth roads which were impassable during and after rain, and which swallowed up a great deal of maintenance money.

We were sure that something could be done with bitumen to stabilize the loose surface of these roads, and the first experiments were with a cut-back bitumen. A report of this first experiment was published in *The R.E. Journal* of June, 1933.

Some results were quite good, but when there was more than 15 per cent. of fine material, results were poor, for the reason that the bitumen balled and could not be dispersed. Wet weather also made the process impossible. Lumps of bitumen meant sweating and messy surfaces in the hot weather, and cut-back bitumen was obviously not the answer.

I then heard that a stable bitumen emulsion had been invented, which enabled dispersion of the bitumen through the soil to be obtained, even in wet weather and, on my way back to India in 1933, I spent a month in America, trying to find out how America solved road problems similar to those we had in India.

Two processes interested me very much, and on my return to India I started on both.

The first of these was the Armour Coat. The theory of this was pure common sense and seemed sound. The usual practice is to lay a carpet of stone pre-coated with bitumen or tar, and roll it in. Great skill is required to get a smooth and level surface, and in warm weather, owing to the thickness of the film on the stone, movement takes place under load, and in many cases the result is corrugation.

The principle of the armour coat is to lay the stone dry, and roll it when dry. This makes it easier to level and enables advantage to be taken of the mechanical bond and frictional resistance of the stone. When it has all been locked together, the surface is wetted and sprayed with bitumen in the form of an emulsion which gives the thinnest film possible on the stone. It is the old story of the carpenter and his glue. The thinner the film the greater the strength. Keying chips are spread and rolled well in, which locks the whole together.

A final seal coat of bitumen emulsion is given which produces a completely waterproof surface. A 1-inch thick carpet constructed by this method has defeated the bullock cart of India with its wobbling wheels and half-round tyres.

The work is quick and, provided materials are ready and the organization good, it is possible to complete over a mile a day. One great advantage of the grouting method is that the surface is ready for traffic 24 hours after completion.

The second was the Stabilization of Soil. In 1930, three years before I visited the aerodrome, the ground engineer of the Glen Martin Airport, Baltimore, decided that something had to be done to make the landing ground safe during wet weather. The soil was a loamy clay, which became a muddy mess after rain. Working in conjunction with an American Bitumuls Company, he sprayed the soil with a diluted stable bitumen emulsion, and worked it into the soil with disc harrows and spring tooth harrows. A sudden cloud-burst turned the field into a morass, but it gradually dried out and was rolled smooth. It was found to be water-resisting and was in perfect condition in 1933, though nothing had been done to it, and no wearing surface had been provided. It was, in fact, the only part of the ground which could be used in wet weather.

A certain amount of interest had been taken in this, but no one had tried to find out what had happened or why the results had been as they were.

Shortly after seeing the runway, I spent a day in the State Highway Laboratory at Washington with Hogentogler, the great soil expert of America. When discussing the result at Baltimore, Hogentogler gave me a theory to account for what had happened.

That theory was the start of the intensive research on soil stabilization which has brought us to the position in which we now stand.

Early in 1934, a runway of stabilized soil was laid for the R.A.F. at Drigh Road, Karachi, which has stood the test of time. In America, millions of square yards have been laid both for aerodrome runways and for road bases, which have proved the value of what I found at Baltimore in 1933.

Many experiments have been carried out in England and Scotland during the past two years with marked success, but it is very difficult to overcome the conservativeness of engineers, many of whom in this country suffer from the old slogans of " it has never been done before " and " it has always been done before."

In the past few years the science of soil mechanics has come very much to the fore. In the beginning, very little was known about the theory of stabilization except that it could be effected by means of bitumen. It has been practised for hundreds of years in Mesopotamia, but the methods adopted were hit or miss, with the consequence that, when failures occurred, it was not possible to analyse them and find out the reason for the failures.

Twenty-five centuries ago, Nebuchadnezzar used asphaltfor stabilizing his mud bricks, and we are now just beginning to know something about it.

A study of the subject of soil mechanics has resulted in the production of one theory, however, which has shown itself to be a success, and intensive research work has been done for the past four years with a view to proving out the theory. Once a theory has been proved, failures can be analysed, the causes explained and understood, and some sort of guarantee provided for success in the future.

It is not suggested that the theory is the only one which will produce permanent and satisfactory results, but experiments in the field have certainly proved it so far. It is based on the known science of soil mechanics and common-sense engineering, and therefore should appeal to all who are interested in soil stabilization and will take the trouble to study the subject.

Soil stabilization means imparting to the soil stability which will enable it to carry a load even in the presence of adverse moisture conditions, and a very great measure of stability can be affected by artificial mechanical grading only.

Some soils are so graded by nature that they will carry a load even when wet. Other soils are stable when dry, but contain particles which have a great affinity for water, and in the presence of moisture lose their stability and begin to flow. For these types of soils, it is necessary to waterproof them to enable them to resist water absorption and remain stable under all conditions.

Water is the great danger where unprotected soils are concerned, whether it is due to the rise and fall of the subsoil water table or to surface water. Therefore the first duty of the engineer is to provide

adequate drainage. By agricultural drains and ditches, the subsoil water can be kept to a known level, which will reduce the absorption by capillarity and, by waterproofing the surface, rain water can be prevented from soaking in and so reducing the stability.

An example of bad drainage is available for all to see outside New Orleans, U.S.A. It was decided to enlarge the city, and a large area was taken in and provided with concrete roads and footpaths.

After all work was completed, the subsoil water was found to be too high, and the area was connected to the main pumping plant. When the subsoil water had been lowered to what was considered a safe level, the shrinkage was so great that the area looked as if an earthquake had visited it. The concrete slabs were cracked and twisted and in some cases had dropped more than a foot.

The value of drainage can be demonstrated by filling a tank with sand and placing a load on the surface of the sand. Water is then allowed to flow in to the top of the tank, and drain through the sand. It will be found that the load will remain firm on the surface. If the flow of the water is then reversed, and it is allowed to enter the tank at the bottom and rise up through the sand, the load will immediately sink. This is the explanation of a quicksand where springs are bubbling up through the sand and holding it in suspension.

Before any stabilization is carried out, the drainage should be dealt with, as it is of the greatest importance.

All soils vary and have different properties and, to enable the different types to be recognized, Hogentogler, the great soil mechanic expert of America, has graded them into groups, according to their different characteristics, as shown by the Particle Size Analysis, the Liquid Limit, the Plastic Limit, and the Plasticity Index.

When the figures for these have been obtained, it is possible, without actual tests, to say with fair accuracy exactly how a particular soil will behave under all conditions, and to give the load which the soil will carry with safety.

It is necessary only to prevent subsoil water rising to within two feet of the surface, and to give it some form of surfacing, according to the load which it has to carry, when dealing with a soil which has natural stability.

The Germans have realized this and have established soil laboratories to examine and determine the safe loads which can be carried by the various soils, but they go no farther.

They do not seem to use their knowledge to the full. When a weak soil is met, it is possible in many cases to so re-grade the soil as to bring it much nearer to the best group grading, and so double or even treble the load-bearing capacity of the soil.

This is the trend of research now being carried out in England, and it should be of inestimable value to engineers.

Stability depends on particle size. There must be sufficient

angular material to get the mechanical bond and frictional resistance, and sufficient cementitious binder to fill all the voids, hold the material together and prevent movement.

Practically all soils are stable under certain conditions, some when holding the optimum moisture content, others when dry. This stability begins to disappear when the conditions are changed.

There are two definite cases where stability can never be obtained in nature, a gravel beach and a peat bog, but these are not soils. In a gravel beach there is no binder and, the stones being rounded, roll over each other. Water only helps to lubricate the movement. Stability can be obtained by adding the binder. Peat is organic and resembles a sponge but, when dried out artificially, becomes hard and waterproof. It can never dry sufficiently in its natural setting to reach this stage.

The stable portion of a sea beach is an example of stability due to the moisture content. When each particle of sand is coated with a very thin film of water, the surface tension of that film is so great that it holds all the particles together and enables heavy loads to be carried.

As the water dries out, the grains of sand fall apart. As the water increases, the surface tension disappears and the grains of sand begin to move.

Clays are hard and stable when completely dry. This is due to the property of adsorption. All colloidal particles are coated with an adsorbed film of moisture which is practically a solid and which can never be removed except by excessive heat, and the heat necessary will completely alter the structure.

In the process of drying, the free water and the capillary water are gradually removed by drainage and evaporation. The microscopically thin film of adsorbed water is left, which has a tensile strength which is almost immeasurable. This film draws the whole together into a voidless mass.

In the presence of water, the adsorbed film very rapidly increases in thickness, causing swell and instability.

A sand and silt soil, such as is found in Mesopotamia and India, will be found stable under certain moisture conditions, due to the surface tension of the thin film of water. A natural hygroscopic soil is met in Baluchistan, which under certain moisture conditions, provides a very fine road surface. However, it very soon disintegrates when dry and with excess moisture becomes running mud.

The science of soil mechanics enables a high degree of stability to be obtained by re-grading without the use of any waterproofing medium. The particle size analysis will show the deficiency with reference to the ideal grading and, by the admixture of the correct material, the grading can be brought up to the best group.

With the gravel base containing the correct amount of soil mortar,

the chances of failure under a concrete slab are small, but with clay, which is so often met in this country, trouble begins. Clay, in shrinking from its plastic state to dryness, loses 27 per cent. of its volume. In the presence of water, the dry clay will swell and cause movement in the sub-base, which will lead to the breaking-up of the road surface.

To get strength as well as stability in a soil a certain amount of clay is essential. Clay has great cohesive strength, and the crushing strength of dry soil will vary according to the amount of clay present. This was proved by making up sample cylinders of soils with varying clay contents, drying them, and then subjecting them to the crushing test. A curve was obtained which started at 500 lb. for the soil with the minimum quantity of clay, rising to 2,600 lb. for the sample with the maximum amount of clay.

The results were reversed when the samples were subjected to water absorption by capillarity. The best graded soil took a load of 20 lb., but the rest collapsed under their own weight.

To make use of the very great strength of the adsorbed film on the clay particles, and to find a means of waterproofing the clay, in such a way that its value was not impaired in the presence of water, has been the object of intensive research work during the past five years.

The great strength of the clay is due to the tensile strength of the adsorbed film of moisture on the fine particles of the clay. The great affinity for moisture and the rapid absorption of water is the cause of weakness and instability.

Research was therefore directed to finding out a method of so waterproofing the fine particles that they would not affect stability in the presence of excess moisture.

The properties of bitumen as a waterproofing agent are well known, but when hot bitumen or hot bitumen cut-back are mixed with fine soil, the bitumen balls and dispersion through the fine soil cannot be obtained.

Hogentogler provided the theory which made it possible to get perfect dispersion. His theory is that to effect stabilization, it is first necessary completely to satisfy the liquid limit of the soil, which means that every particle must be coated with a thin film of water. Using the water as a carrier and applying the bitumen in the form of a special emulsion, in which the bitumen particles are as finely divided as the soil particles themselves, the bitumen will be carried wherever the water is, and perfect dispersion will result. The emulsion must be of such a nature that the bitumen will only coagulate by the evaporation of the water.

As the water dries out, the adsorbed film on the soil particles will draw a thin film of bitumen around them, thereby preventing them from absorbing a detrimental amount of moisture, and practically destroying capillarity. In a properly stabilized and waterproofed

soil, absorption is reduced from up to 25 per cent. for the untreated to under 1·5 per cent. for the treated soil.

The adsorbed film of water is partially replaced by an adsorbed film of bitumen, and this has been proved by the fact that it is not possible to extract all the bitumen added to soil, even with boiling carbon tetrachloride.

This is the theory of soil stabilization, which has been proved both in the laboratory as well as in the field.

While research still goes on, it is already possible to determine by simple tests whether a particular soil can be economically stabilized and waterproofed in its natural state, or whether an admixture is necessary. It can also be stated exactly how the soil will behave and the safe load that can be put upon it. With a good soil, the percentage of stabilizer required varies with the clay content. This waterproofed clay is the cementitious binder which fills the voids, holds the mass together, and gives the strength.

With a soil containing a large percentage of colloidal clay, more bitumen will be necessary, and the amount required may make stabilization an uneconomic proposition. It is usually possible to remedy this by prescribing for the necessary re-grading of the soil.

Some tests are necessary to ascertain the measure of stability which can be given to the soil, and certain ones have been developed which more or less reproduce the conditions obtained in the field. These will give relative values between soils stabilized and unstabilized, and have great value.

It is not possible to lay down any hard and fast rules regarding stabilization, but only general principles. Every case has to be treated on its merits, to get the best and most economical results. From the work which has been done in England and Scotland in 1937, and which has been through a severe winter, it appears that successful stabilization of soils has been effected.

In America, many millions of square yards have been laid with complete success and one aerodrome runway which is still completely satisfactory, goes back to 1930. There is no reason why similar results should not be obtained in England which should stand the effect of time and weather, as has been the case in America.

It might be asked how and where can stabilized soil be used, and if used how thick should it be.

For Roads.

The majority of failures in modern roads can be traced to base failures.

A modern road consists of three separate parts.

(*a*) Road bed or sub-base.
(*b*) Foundation.
(*c*) Wearing surface.

A great deal of time and money are spent on the foundations and the wearing surface, but very little consideration is given to the road bed or sub-base. Any structure, whether a road or a building, if founded on a weak sub-base, will fail. Hard and fast specifications are laid down but practically none gives any consideration to the sub-base.

Where clay is met, it is common practice to specify three inches of sand or ashes to be rolled in preparatory to laying the stone pitching or concrete foundation. If the drainage has been properly catered for, the clay will dry out and shrink, causing movement.

This is where stabilization can be of immense value. By re-grading the soil, *i.e.*, by adding the particle sizes which the soil lacks, it can be brought as near as possible to Hogentogler's A1 grading. By this the stability and the load bearing capacity will be increased, and the shrinkage in the soil can be reduced to below 2 per cent. The theory of soil mechanics will show how this can be done. The quantity of clay is reduced, by the addition of granular material, to the correct proportion to give the greatest cohesive strength with the minimum of movement in the presence of water.

By calculating the correct quantity of sand and ashes, and by ploughing them into the clay, then consolidating with a sheep's foot tamping roller, a stable mass can be obtained which will make a perfectly safe road bed.

By going farther and waterproofing the top few inches of the re-graded soil, a waterproof raft can be obtained in which shrink, swell and capillarity have been reduced to an absolute minimum. A concrete slab laid on this waterproof raft will have no bridging points and it will therefore be possible to reduce the depth, as well as the quantity of reinforcement.

For secondary roads, footpaths, parade grounds, etc., stabilized soil can be used as the foundation itself, and merely given a thin wearing surface.

As regards thickness, this will depend on the load to be carried. For footpaths, playgrounds, three inches will normally be sufficient. For parade grounds and light traffic roads, four inches will be good enough. It will not be necessary to go beyond eight inches. At Aldershot, five inches of a stabilized waterproof base is carrying tanks and heavy M.T. with only a three-quarter-inch granite armour coat as a surface. In America, an eight-inch stabilized quarry-waste mat is carrying heavy bombing planes over saturated mud.

The next point to be considered is how to effect stabilization and ensure complete dispersion of the bitumen through the soil.

This can be done in two ways:

(*a*) By picking up the soil and passing it through a paddle mixer.

(*b*) By mixing *in situ* with farm machinery.

For small areas such as playgrounds, parking areas and footpaths, where there is not room to operate farm machinery, the best results are obtained by machine mixing, preferably in paddle mixers.

After the analysis and the laboratory specifications have been completed, the soil is scarified to the depth required, and well broken up. It is then picked up and placed in the mixer with the correct amount of admixture if necessary, and the determined amount of stabilizer is added. If it is found necessary, more water is added to ensure easy mixing and, when the soil is of a uniform colour, it is spread to the required depth and screeded.

Up to three inches depth, as soon as it will take the weight of a light roller of 10 cwt., rolling is started and finished off with a heavy roller. The water has to dry out and, as it dries, the soil will shrink and crack. If rolled at the plastic limit, all cracks will be closed. It is then left until it is completely dried out. The bitumen in the stabilizer should only coagulate on the evaporation of the water, and the strength will not be obtained until the mass is dry. Once it is dry, it will not again absorb detrimental water, and it should then be sealed. It should never be sealed until it is dry, otherwise it will never get hard.

As stabilized soil has no great resistance to abrasion, after sealing it should be given an armour coat of stone chippings and quick setting bitumen emulsion, the thickness varying according to the traffic which it has to carry.

For large jobs, mixing in place is most economical. This is done with farm tractors, disc harrows and spring tooth harrows.

The ground is first cleared of grass sods and any roots. It is then scarified to the required depth, any admixture added and the surface thoroughly broken up and mixed by means of disc harrows. The ground is then wetted, and stabilizer is sprayed from a tank distributor at a specified rate, followed immediately by a spring tooth harrow to disperse the bitumen through the soil.

When partial drying has taken place, rolling is started with a sheep's foot roller. Before complete consolidation has been effected, the surface is graded with a drag and the rolling is finished off with a tandem roller.

When thoroughly dried out, it should be given a seal coat and surfaced, the thickness depending on the traffic which has to be carried.

America has now developed a machine which picks up the soil after it has been formed into windrows by graders, passes it through a long paddle mixer where the stabilizer and water are added and passes it out behind, ready to be spread to the required depth. The use of this machine makes drying much quicker, and extends the time during which soil stabilization can be carried out. The machine is heavy and expensive and can only be economically used when a

large area, such as the runways for an aerodrome or a long length of road are to be constructed.

The presence of water prevents the coagulation of the bitumen and the setting of the stabilized material. This fact makes it possible to mix material at a central mixing plant and carry it to site in trucks.

During 1937 and 1938, various works have been carried out. In June, 1937, a large area was stabilized and surfaced in front of the hangars at Prestwick Aerodrome. This was done with farm machinery and has been successful. It has stood up for two winters and is in excellent condition.

In July, 1937, a smaller area was stabilized for the same purpose at Woodley Aerodrome, near Reading, which has been completely satisfactory. It has stood up to the dripping of oil from standing aeroplanes.

In July, 1937, half a mile of stabilized road base was constructed at Aldershot, and surfaced with an armour coat of granite chippings, three-quarters of an inch thick. This has been continually under water in parts of the road, due to inadequate drainage, and has stood without damage the traffic of tanks and heavy mechanical transport through two winters.

In 1938 an area was stabilized at Gatwick Aerodrome, and a large parking area was completed at Bolton, which has been so successful that further areas are contemplated for car parks and school playgrounds.

Only practical demonstrations will convince engineers of the value of any new form of construction, but, from the work carried out and its behaviour during severe winter, it appears that effective soil stabilization has been successfully accomplished.

It must be realized, however, that it requires just as much care and attention to detail as any other more expensive form of construction.

Soil stabilization is not like a patent medicine which will cure all ills, and there are cases where it would not be sound engineering to attempt it. The science of soil mechanics will show where and how it can be used with economy and advantage.

SOME COMMENTS ON BRIGADIER HASWELL'S LECTURE ON SOIL STABILIZATION.

By BRIGADIER-GENERAL E. G. WACE, C.B., D.S.O.

I WAS interested to have the opportunity of listening to the lecture on "The Application of Soil Mechanics to Road Construction and the uses of Bitumen Emulsions," by Brigadier C. H. Haswell on the 19th January, 1939, and I was surprised at the very confident tone in which he enunciated both the theories underlying the soil stabilization methods which he put forward and, in respect to those theories also, the practical recommendations which he made.

I am connected with a company which has also carried out a great deal of work on soil stabilization and earth mix and I must say that our views on many of the crucial problems involved differ rather strongly from his and from those of McKesson, an expert of a company in the U.S.A., associated with Brigadier Haswell's company, whose views the latter largely follows. My firm has, in the past, pursued technical discussions with Brigadier Haswell's technical officers, with the intention of trying to bring these views into closer agreement. Unfortunately, these technical discussions have not yet been brought to a conclusion and this is largely because that company is still considering the evidence we have placed before them. I should like, however, to outline the points in which I think their views are in error, and to indicate what I think are the correct lines on which this type of work should be developed, so that large-scale failures may be avoided.

I do not in any way wish to condemn the whole idea of soil stabilization with bitumen emulsion which, on the contrary, I am sure is one which may be developed fruitfully, but I am fearful, on the other hand, that unsuccessful work may result in an untimely end to progress in this direction.

My interpretation of the reason for non-success is that the basic tests, on which McKesson and his association would have us determine the stability of a soil for this type of work, are unsound. Their scheme of testing embodies, in essentials, the Capillary Absorption Test, which sets out to determine how fast the treated material will absorb water and, subsequently, the Stability Test, which seeks to show what its bearing capacity is after attack by water under standard conditions. *The Capillary Absorption Test is*

not a measure of the water absorption at equilibrium and the Stability Test which follows it is not a measure of bearing capacity. I have prepared slurries of certain sand/clay soils, which were semi-fluid and yet which gave, in the standard apparatus for the Stability Test, a resistance which would characterize them as suitable for bearing traffic loads. It is obvious that any work carried out on the indications of such tests must necessarily run a very grave risk of failure.

In contradistinction to these tests, with their rather complicated apparatus, my company has found very simple tests which, moreover, are much more severe than those recommended by Brigadier Haswell and, in our view, based on practical experience, they are much more reliable. I published these tests, in some detail, in a paper which I contributed last December to the Association of Asphalt Paving Technologists of America and, for the present purpose, I may say that they consist in the preparation of mixed samples of earth and emulsion, in which the bitumen content is varied from 3 per cent. up to about 9 per cent. These samples are then dried, immersed totally in water until they have absorbed as much water as possible and then tested by any suitable technique for resistance to deformation. In spite of their simpler sound, these tests do show the state of affairs at equilibrium between water and soil mix. I have placed evidence of this fact at Brigadier Haswell's disposal and, so far, he has not objected to my conclusions.

Those interested in the subject may get a very good idea of Brigadier Haswell's contentions, in greater detail than he had time to enter into at the lecture, by reading a paper by McKesson, which appeared in the *Proceedings of the 15th Annual Meeting of the Highways Research Board, U.S.A.*, 1935, pages 343 to 391. In reading this paper, too, there are certain interesting discrepancies which seem to require more explanation than is, in fact, vouchsafed. For instance, in this paper, we find methods of calculation advanced by which the percentage of bitumen should be determined in soil mixing and yet in examples of practical work carried out, given at the conclusion of the paper, it is difficult to see how these calculations have been used, because the bitumen contents of the work do not seem to be in line with the methods put forward. For instance, the job at Glen Martin Airport would seem to contain somewhere about 5 per cent. of bitumen, which is much more than we should expect from the first half of the paper. It seems, in fact, that the bitumen contents have been quite rightly apportioned by actual examination of the soil and, possibly, also by actual control on the site of operation. If this has been done, I would agree that this is the correct procedure and certainly from what I know of this work, the bitumen content for good results would be about what has, in fact, been put in.

It will, perhaps, be interesting for me to quote one or two examples of work done by my company, which prove that the ideas which I put forward can be substantiated by practical experience. There was, for instance, a very early piece of Terolas earth mix carried out at Aldershot in 1932. A Foden lorry, loaded to 17 tons, was put over this piece of road 24 hours after its opening to traffic and caused no marking of the surface. There was also interesting work which we were able to carry out at "C" crossing, Netheravon, in conjunction with the Royal Engineers Board, in 1934. There is further work of this type at Southampton and Doncaster Airports and in the early years before, I believe, Brigadier Haswell's company was in the field at all, we did much work at Croydon Airport, which, owing to subsequent development of the airport, is not now extant but which gave excellent service up to the time of its removal. I could further instance a section of the French military road across the Sahara Desert, from Touggourt to Ouargla, a considerable portion of the road between Mexico City and Laredo and, further, many extensive roads at Valcartier Camp in Canada.

In point of fact, the *working* methods recommended by Brigadier Haswell are not so very different from those which I should recommend, but my tests would lead me to reject many soils which he would apparently accept and, furthermore, I would not make any pretence of using the low bitumen contents which the formulæ put forward by McKesson would suggest. I rarely, if ever, found a soil which could do with less than 3 per cent. of bitumen in the final mix and which would not, in fact, benefit by having 5 per cent.

Another point is the recommendation made by McKesson and his associates that clay should be added to soils which contain less than a certain quantity of it originally present. This procedure is presumably based on the known fact that in the case of sands exhibiting low cohesion, the addition of fine material, such as clay or filler, will convert these unstable gradings into something capable of exerting a reasonable bearing capacity. It may be admitted that in the case of this particular type of material this is true, as long as the range of water contents over which observations are made is within a certain restricted category. However, if a mixture has to contain 25 per cent. to 30 per cent. of clay, in order to give it the requisite bearing capacity, it will probably not prove possible to maintain this mixture within the restricted range of water contents necessary for it to show this bearing capacity, because of the avidity with which the clay will take up water and swell. By reason of the hydrophilic nature of the clay and of its fine dispersion, it is one of the most difficult materials to waterproof by using the normal rather low percentages of stable emulsion and with the hydrophilic type of clay, at any rate, it is not possible, with 3 per cent. or 5 per cent.

of bitumen, or even with substantially higher percentages, to restrict the absorption of water and consequent swelling to a useful extent. It does not need any imagination to picture that a material containing 25 per cent. to 30 per cent. of such clay will also swell to a considerable extent, even as the clay does itself, and with the most disastrous results.

There is, of course, a restricted class of clays less hydrophilic than those known in Great Britain, to which the full severity of this censure need not apply, but, in the recommendations which have been made to incorporate clay in this type of work, no distinction as to the type of clay to use has ever, to my knowledge, been made.

Therefore, summing up what I have said in this respect, it seems evident to me that although in certain cases, mainly involving cohesionless sands, the bearing capacity can be improved by the addition of clay, it becomes, by reason of the presence of this latter material, almost impossible to secure adequate waterproofing with economic amounts of bitumen and, therefore, the purpose of the incorporation of the clay is defeated. There are many soils of loamy type in this country, containing only 5 per cent. or 10 per cent. of material passing 200 mesh sieve, which are perfectly capable of giving good bearing capacity and of being adequately waterproofed by the addition of stable emulsion, to which the addition of any large percentage of clay, such as is recommended by McKesson, is an incorrect step.

In conclusion, therefore, I would say that I think soil stabilization by bituminous emulsion is a sound project, with a big future sphere of development. The working methods which my company has developed allow of satisfactory work, if one is certain of the suitability of the soil and of the method of construction. I do not think Brigadier Haswell's working methods differ from those which we have worked out in any essential particular, except, perhaps, as regards this addition of clay and as regards more rigid specification of certain factors, for example, the thickness of the stabilized layer, which, in my view, cannot be specified in any general manner.

Brigadier Haswell's and McKesson's theories cannot in my opinion be advanced as a basis of any satisfactory method of construction. The only satisfactory way at present is the empirical one of going to the job, examining the soil by adequately severe tests, summing up the traffic conditions and probable load and determining the details of construction in the light of experience. This, after all, is done in ordinary road making and, working in this way, I feel that a considerable percentage of satisfactory jobs can be obtained at a reasonable cost and, in some cases, this procedure forms the only practicable way of providing an improvement on a mud road.

My only aim in making these criticisms is to ensure that the

project of soil stabilization as a whole is not turned down because of a rigid compliance with theories which have been advanced, which have little, from the point of view of practical confirmation, to recommend them.

I was recently much heartened to find that an American soil physicist, who is also associated with large-scale stabilization projects in one of the largest States there, agrees very substantially with my views and has been spending some time in trying to elucidate the difficulties which are met with in endeavouring to follow out the procedure which has been recommended by Brigadier Haswell. This renders me all the more confident that something further in the way of a more complete theory must be sought.

APPROXIMATE METHODS OF SQUARING THE CIRCLE.

By Major J. G. HEARD, M.C., R.E.

THE following approximate methods of determining the side of the equivalent square, applicable to solution by field geometry, may be of some interest.

Method A entails no linear measurement, but method B does require such a unit.

A. Reference figure 1.

Determine point O the centre of the circle, and draw the diameter AOB, and the tangent BX.

At points O and B, respectively, construct the angles BOC=60°, and OBD=45°.

Through point E, the intersection of OC and BD, draw the line FEG perpendicular to BX, meeting the circle in point F, and the tangent BX in point G.

Then,

$FG = 1{\cdot}77335\ .r.$ $\qquad \sqrt{\pi}\,r. = 1{\cdot}77245\ .r.$

Linear error $= +\ 0.0009\ .r.$

Superficial error $= +\ 0.0032\ .r.^2$

Proof

Since AB and FG are perpendicular to BX,

$$FG = OB + (OF^2 - BG^2)^{\frac{1}{2}} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

Reference figure 2

$$OB = r \quad \text{Let } EH = x$$

Then,

$$r = x\left(1 + \frac{1}{\sqrt{3}}\right) \quad \ldots\ldots\ldots\ldots\ldots (2)$$

$$x = r\left(\frac{\sqrt{3}}{1+\sqrt{3}}\right) \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Now $BG = EH = x$

Substituting values in equation (1)

$$FG = r + r\left(1 - \left(\frac{\sqrt{3}}{1+\sqrt{3}}\right)^2\right)^{\frac{1}{2}}$$

$$FG = 1{\cdot}77335\ .r.$$

B. Reference figure 3.

Draw a line AB = 39 units.
In AB mark point C, where AC = 17 units, and CB = 22 units.
At points A and C erect the perpendiculars, AE and CD, to the line AB.
Make CD = r.
Join BD, and produce the line BD to meet AE in point E.
Then,

$$\frac{AE}{CD} = \frac{39}{22}$$

$$AE = \frac{39}{22} r$$

$$\therefore AE = 1{\cdot}7727 \ .r. \qquad \sqrt{\pi}.r = 1{\cdot}77245 \ .r$$

Linear error $= +0{\cdot}00027 \ .r$

Superficial error $= +0{\cdot}00096 \ .r^2$

It is, perhaps, of interest to note that the number 22 occurs in the fractional approximations for both π and $\sqrt{\pi}$.

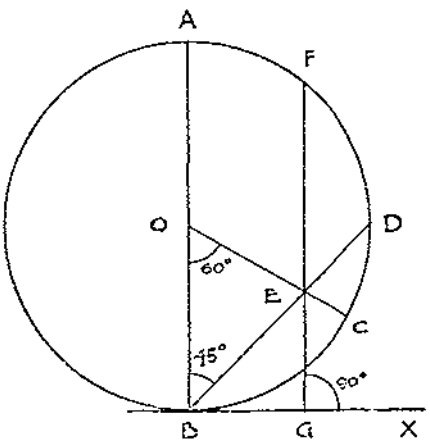


FIG. 1.

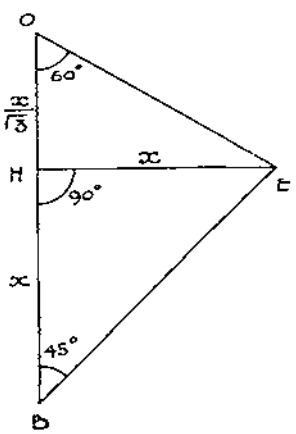


FIG. 2.

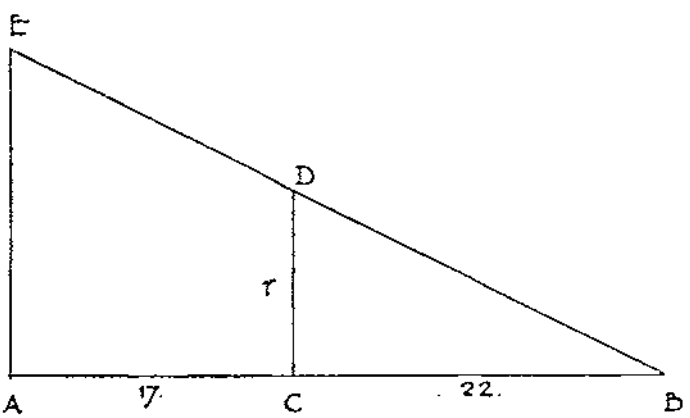


FIG. 3.

AN IMPROVISED CONCRETE-TESTING MACHINE.

By S. R. Arnold, A.M.I.Mech.E., A.M.I.E.E.

1. The writer was recently concerned with a contract in which large quantities of aluminous and calcium concretes were needed for the construction of blast-furnace equipment. To avoid cracking and consequent disintegration of the structures whilst the equipment they supported was being raised to the high temperatures common to the melting process, it was important to keep a very close check upon the composition and puddling of the various aggregates employed.

2. To do this properly would have involved the purchase and installation of a complete testing plant, with personnel to operate it. Although the project was extensive it was not deemed by the directors to be sufficiently so to warrant this expenditure.

3. As it is not uncommon in the construction of steelworks, three-shift working was employed throughout the project, and certain difficulties attendant on the operation of the first portion of the equipment to be placed in service, with consequent expensive treatment under the maintenance clauses, caused the writer to regard the common slump test with some suspicion.

4. Enquiries made from the construction foreman elicited the facts that the slump had been carefully watched and had, in many cases under suspicion, actually been observed by the customers' consulting engineer. Working conditions upon a three-shift basis throughout the winter months introduce very arduous conditions for the construction gangs and, no matter how well lighted the work may be, it is not easy to avoid the use of dirty water (perhaps contaminated by ammonia leakages from the by-product plant) and the admixture of dirt with the aggregate. Further, the pyrogenic reduction of the carbonate ores of Northamptonshire, and the simultaneous operation of coke-oven plant adjacent to the construction site, release into the atmosphere quantities of fine black dust which seems to penetrate everywhere. The slump test seemed to be quite incapable of detecting a suspicious mix under these conditions.

5. Consideration was given to making tests on samples from the daily mix but, despite elaborate precautions, the setting time and the postal interval invariably delayed the results and prevented any useful results being obtained in time to be of use.

6. The writer then attempted to develop a testing machine which could be made up of materials easily available without attracting

the attention of audit. The official tests of concretes are usually made in the laboratory by crushing six-inch cubes, and the apparatus necessary to do this is large and expensive. It was not possible to improvise such apparatus. Cement itself is tested in tension and this method has been accepted for many years, provided care is taken to ensure a geometrically similar sample. The sample most easily made under site conditions is a rectangular beam, which can be stressed in tension by the simple expedient of subjecting it to a bending moment. There are several objections to testing samples in tension, but these are really outweighed by the results, which show suspected cases that may be readily referred for official tests with entire confidence as to the result. Care should, however, be taken not to allow any possible legal process to rest unsupported upon the rough tests about to be described.

7. The device consists of a baseboard 24 in. by 8 in. by 1 in. thick, upon which are fastened two square dogs. This baseboard can be attached to any convenient wall in the construction office. The samples are tested in the form of a beam 2 in. by 2 in. by 24 in. long, which is broken by the stresses induced in it at the point of flexure. The stresses are caused by subjecting the beam to a gradually increasing bending moment set up by a weight at the free end.

8. The writer began by using beams 1 in. by 1 in. by 18 in. long, but it was found that, when examining aggregates containing $\frac{3}{4}$ in. ballast, the presence of one large pebble near the line of maximum bending moment would invalidate the results. Since the present size of 2 in. by 2 in. by 24 in. beam has been in use this disability has not been apparent but occasional cases of absurd results arise; these are obvious by an examination.

9. The samples are made up in wooden moulds and are cast with exactly the same precautions against ramming, over-filling, etc., as the B.E.S.A. standard briquette. It will be found that the beams can be withdrawn from the moulds much more easily if the latter are lined with a thin piece of paper and the sample lifted out in it.

10. The setting time before test is entirely a matter for local decision but the best results will be obtained in the case of neat cement by carefully observing the B.E.S.A. rules—for concretes three beams broken 48 hours after sampling and three more 96 hours after sampling will give a very fair idea of the quality of the sample. It is best to allow the moulds to remain in a small cupboard containing an open dish of water whilst they are setting; this precaution prevents any excess water, above that needed to complete the chemical reaction of setting, from evaporating and renders the sample more alike in consistency to the mass it represents.

11. When set, the samples may be removed from their moulds and placed gently between the dogs, the rear end of the sample registering with the rear end of the dog marked "A." The saddle "E" carrying

the weight pan " F " is now gently slid along to the free end of the beam, the end of " E " registering with the free end. Failure will always take place along the line " C—D," a section at which it is easy to determine the skin-stress to which the beam has been subjected.

12. In order to avoid any complications due to the sudden addition of large increments of weight, the pan " F " should be filled either with small shot or water added from a small can. It should be noted that no proved weights are needed, the total load being assessed by means of a suitable spring balance at " H." Water has been found to be the most suitable medium, when fed into the can by an ordinary " Kaye " pattern oil feeder.

13. The weight should now be applied and it will be noted that the beam will deflect slightly and finally fracture, when additions of weight should promptly cease. The pan should be weighed together with the saddle " E." It will be found that a spring balance reading from 0—10 pounds, graduated in tenths, will suffice for all practical purposes.

14. The skin stress to which the outer layer of the beam is subjected may be determined by simple substitution in the formula :—

$$M = fz,$$

where

M = the bending moment in lb./in.
f = the skin stress in lb./sq. in.
z = the section modulus in inch cube units.

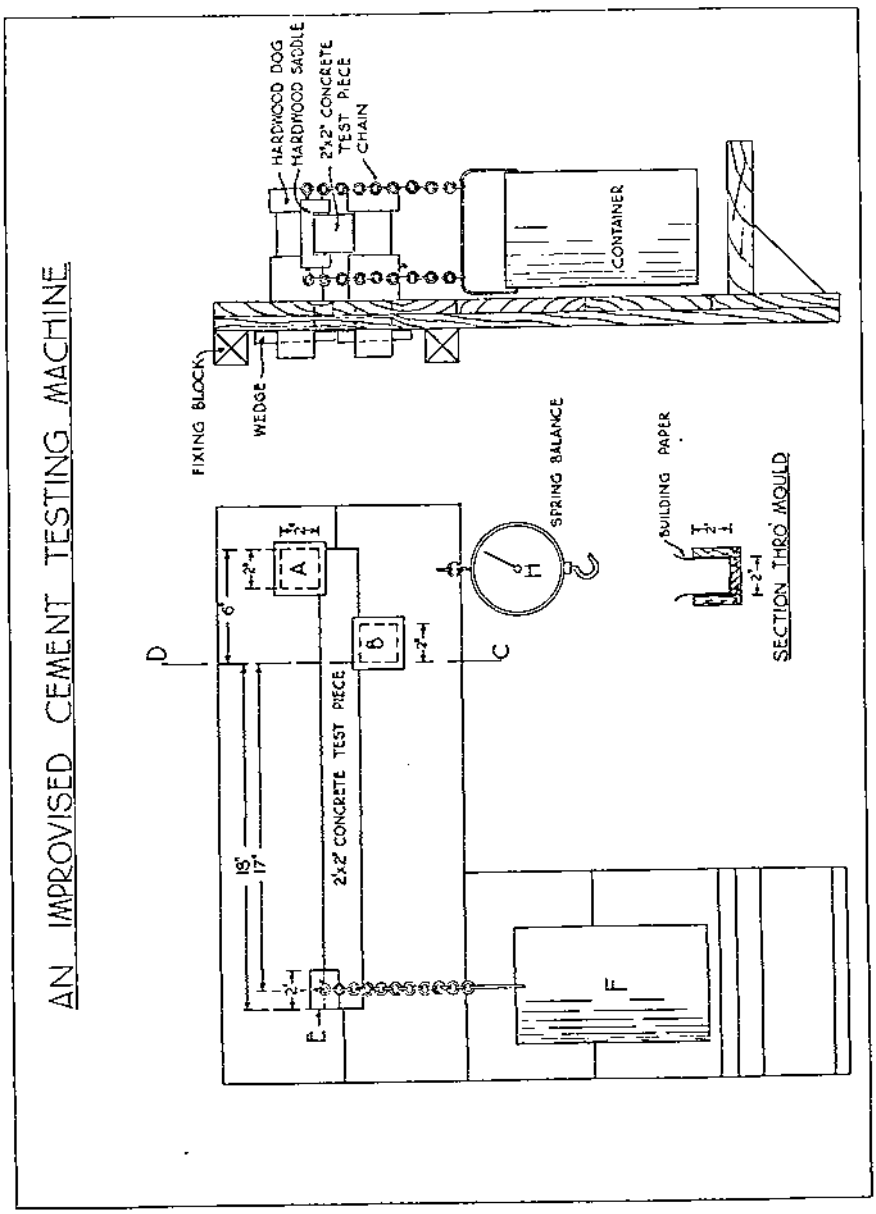
For 2 in. by 2 in. by 24 in. beams, substitution yields the following result. (It should be noted that the effective length of a 24-in. beam is from the centre line of load saddle to line of flexure, *i.e.*, 17 in.)

Tensile stress = 12·75 W. lb./sq. in., which stress is of the same kind and nature as that obtained in simple tension in the briquette machine.

As the stress is at a maximum upon the upper skin of the sample at section " C—D," serious error would be introduced by modifying this equation to take account of the comparatively unstressed material surrounding the neutral axis.

15. The tensile stress to be required is a matter really for local decision. The writer is not aware of any authority whereby an empirical relation between tensile and compressive crippling loads can be established. It should be noted that samples were taken only from the daily mixes and not from aggregates specially prepared for purposes of experiment and it is thus not really possible to state if there are grounds for assuming such a relation to exist.

16. The maximum stress which can be applied by the machine described is 127·5 lb. per sq. in. (10 by 12·75) and no sample known


AN IMPROVISED CEMENT TESTING MACHINE
HARDWOOD DOG
HARDWOOD SADDLE
2"x2" CONCRETE TEST PIECE
CHAIN
CONTAINER
FIXING BLOCK
WEDGE
SPRING BALANCE
BUILDING PAPER
SECTION THRO' MOULD
2"x2" CONCRETE TEST PIECE
A
B
C
D
E
F
G
H
I
6'
18"
17"

to the writer has yet sustained this load, though some have approached it. As a rough guide, the following table may be employed :—

CONCRETES.

	Tensile test in lb./sq. in. 48 hours after sampling.	Tensile test in lb./sq. in. 96 hours after sampling.
(*a*)	Below 55	Below 65
(*b*)	55–70	65–80
(*c*)	70–80	80–90
(*d*)	80–90	90–100

(*a*) Reject.
(*b*) Retain under protest.
(*c*) Good.
(*d*) Very good.

The presence of dirt gave a low tensile test value at a satisfactory slump of three inches.

It is true that all the results are affected by the method of mixing and the rate of adding water, but as the samples are taken from the actual aggregate employed, good mixing is represented by a good test, which is the thing we all desire.

17. The writer is not suggesting that there is any case for tensile testing of concretes replacing compressive tests; in fact it is most probable that the greatest value of the device lies in the psychological effect it has upon those who know of its existence.

There is no doubt that the general quality of cement (at least at home stations) is such, that very good results may be obtained by taking reasonable precautions against dirt, bad puddling and excess of water, and if the presence of a testing device, no matter how improvised, can persuade those responsible to act reasonably without surveillance, it can be said to have accomplished its object.

TALES OF A MALAYAN LABOUR FORCE.

By "MATA KACHA."

THE TREE.

THE little white launch was making its way slowly eastwards down the Straits of Johore against the first of the flooding tide. The rain-squall which had been threatening us had passed away to the south-west and the sun was once more shining strongly and brightly out of a clear blue sky. We were off Seletar, where the advancing works of the Singapore Naval Base showed scars of orange earth and grey masonry on the olive green face of the surrounding mangrove. To the north lay Johore, whose dark green fringe, skirting the royal blue of the Straits, rose through a belt of rubber trees displaying every shade of green to where the towering mass of Lunchoo frowned down at his own reflection in the water. Beyond, again, were the purples and blues of succeeding ranges of tree-covered hills extending to the extreme horizon, where Pulai in the west and Muntahak in the east kept their dual watch over the land of tigers.

Before us, sharply dividing the Straits by the wedge-shaped promontory at its western end; lay Pulau* Ubin, the Island of Granite, its slopes densely covered with jungle save where the quarries, glistening silver-grey in the sunlight, gave evidence of man's spoiling hand. Here, in the dark recess of a placid little bay, was the small palm-roofed dwelling of some fisherman now busy with nets and boat on the shelving beach. Behind him the wooded slopes rose abruptly to the highest point in the island and there, bravely displaying his naked trunk and withered branches to the azure sky, stood an immense, dead tree. And then it was that I first learnt about the "*pokok kramat.*"

* * * * *

"Yes," said my host, "that's a sacred tree. Some call them '*pokok hantu*'—haunted trees. They are places of prayer for the Chinese and you will often find little shrines built at their roots. The trees must never be felled or cut and the superstition runs that they continue to stand like that, leafless, for ever."

"We had to get rid of one the other day," he went on, "but we

* Pulau = island.

could not get a coolie, Chinese, Tamil or Malay, to touch it at any price. They all said death would come to them if they did. But the tree had to go, so we hit on the bright idea of fetching in a gang of coolies who wouldn't know that this particular tree was '*kramat*' and getting it down and out of the way before they could find out. So away went a lorry one fine morning, all the way into Singapore, and brought back half a dozen Chinese coolies to do the job. As soon as they arrived they were given tools and a rope and told to get the tree down as quickly as possible."

"And what happened?" I asked, while my host lit himself another cigarette.

"Well," he answered, enveloped for an instant in a cloud of his own smoke, "they got it down all right, but the old tree had its own back on them. In falling, it twisted on its base and crashed to earth among the party of coolies on the rope. Two were killed outright and four others seriously injured. It accounted for seven men in all, for the young European engineer responsible for the job died of malaria in the general hospital a fortnight later. So, perhaps, there is something in it after all."

By the time he had finished, Pulau Ubin had slipped far astern and was now nothing but a jet-black silhouette against the western sky. Clear-cut at its summit stood the tree. And, watching it, I could not help thinking, as the launch chugged eastwards to meet the winking of the red and white channel buoys off Changi, that it would not be long before those quarrymen would be facing a similar problem.

* * * * *

But it was not the quarrymen of Pulau Ubin, after all, who were to be the next to deal with a sacred tree. Casting my mind back across the intervening period of time, it seems that the incidents I am about to relate followed immediately upon my discovery that such things as sacred trees existed at all, but a glance at my diary reveals the fact that it was six months later that I was brought suddenly face to face with the problem myself.

We were engaged at that time in clearing a large piece of land for a new Government building scheme. The area which had been acquired for this purpose was occupied by a great number of Chinese squatters, with their pigs and pig wallows and their fowls and children and their dogs. There is a saying that in China there are four hundred million Chinamen and four thousand million pigs and between them both there is not much room for anything else—which may, or may not, be true of China proper, but it was certainly most applicable to this "little China" of ours in Singapore. And when, after months of warnings and threats and cajolery, we at

last freed ourselves of this living incubus and had torn up the remaining thin concrete floors of their dwellings, drained their pig wallows, and filled up their wells and cess-pits, the time came to start clearing the ground of their trees.

So, once more, the improving hand of civilization began its wrestling match with nature and in that valley the grunting and snuffling of swine gave place to the ring of axe and hook, while the surveyor peered through his level where, for generations, John Chinaman had rested on his hoe to survey his little rent-free world.

At the time of which I am telling we were still at the beginning of our labours, but I had already a hundred or so Tamil coolies working with me, some clearing the line for the road which was to give access to this hitherto secluded region, others cutting tracks through the undergrowth for the surveyors, and others again bringing down one after another of the ancient trees which occupied the sites destined for buildings. Sweet-scented chembagahs, mighty angsanas, and the vulgar rubber tree fell crashing to the ground in company with a host of mangosteen and jack-fruit trees, guavas, lime-fruit, banana palms and giant bamboos. And on every side there rose straight into the still, hot sky, blue columns of smoke from countless bonfires. And in due course we came to The Tree.

There was nothing to distinguish that particular tree from many others like it. I remember it quite clearly before it was felled, a great, spreading chembagah with thick broad leaves and, high in its top, clusters of those powerfully scented blossoms which the Chinese maidens love to wear behind the ear, like the roses worn by their sisters in Spain. It stood on the bank of a deep-scored malodorous stream, within a stone's throw of what had been a Chinese dwelling. But all that remained of that homestead was a square of hard trampled earth which had been the floor, a tumbled pile of mud bricks which had until recently supported the great iron boilers for the pigs' food and the roughly concreted well-head. The scattered rubbish which lay around consisted only of the usual empty stoneware pickle jars, broken paper umbrellas and rags, with a few smouldering butts of joss-sticks on a broken green earthenware holder, such as might have stood before the figures of Longevity, Prosperity and Fruitfulness, which are to be found in every Chinese house from the highest to the lowest in the land.

Now, possibly because the coolies were strangers to the place, or possibly due to the blandishments of a Christian overseer (I know not which), the axe was laid to the root of The Tree. I was not there to see it fall, and I do not know what unavailing protests, if any, were made, or by whom. But it must have taken them a good two hours to notch those massive wooden buttresses and to saw through that

solid five foot bole. So it has always remained a wonder to me that the trouble did not start earlier than it did, and before The Tree, with a last mighty rushing of wind through its leaves, and a tearing and cracking of branches, finally measured its full length astride the stream, like the twisted remnants of some demolished bridge.

But then whatever discipline or threats had hitherto kept the men at their work availed no more and pandemonium broke loose. The sound of a yelling babel of agitated voices drifted up to the little palm leaf hut, which served me as an office. Clear above all came a long, drawn-out, high-pitched wailing, which carried me back irresistibly to a certain North Foreland camp, where the regimental butcher had thrown a fit and was pinioned to the ground by four lusty men until the worst paroxysms were over.

My first impression, as I hurried down towards that turmoil, was that a tree had fallen on some luckless coolie, and I was not prepared for the scene which met my gaze on the bank of the stream. For it was not the tree itself but the fear of death which had fallen upon that little gang of half-naked Tamils on that sticky October morning. On the ground in the shade of a nearby tree lay writhing in the grasp of two of his fellows the form of one of the oldest coolies, with the white foam of madness bubbling below his long and unkempt grey moustache. Every now and then the old man raised himself with a superhuman effort and emitted the long wailing sound which had first attracted my attention. And as he did so his guardians fell upon him and forced him once more upon his back until the sound died as it had come, drowned in the foaming froth which welled up again from between the parched old lips. And all the while the other coolies in their motley red and white loincloths stood around wringing their hands and gaggling like a flock of geese in a farmyard, while from all around their comrades of the other gangs hurried up to see what was the matter, and so within a few moments of my arrival the whole labour force was concentrated babbling and shrieking round the figure of one poor old man who, I thought, had just had a stroke.

The overseer it was who spoke first, and it was with that sudden little clutch at the heart which one experienced at school when sent for by the headmaster that I heard him say, quietly enough considering the circumstances, "We have felled a '*pokok hantu*', Tuan*; This was a sacred tree."

It is difficult for me clearly to remember all that happened in the minutes immediately following that announcement. The air was full of the rich smell of the freshly sawn timber mingled with wood smoke from a neighbouring fire. The old man, lapsed now into

* Tuan = master.

quietness in the shade of his rambutan tree close at hand, still trembled spasmodically as the seizure gradually left him. Around us stood a ring of surly-looking frightened coolies, upon whom the overseer poured forth a burbling stream of their own language without apparent effect. Not one of them stirred to take up the tool which he had cast on the ground—not a man turned away to resume his interrupted work.

"It is no use, Tuan," said the overseer at length, "they will not work any more. They say that the evil spirits which guard this tree will enter into all of us and that nothing but bad luck, and ill-health, and death can come to us all."

." What nonsense!" I replied and, stepping on to the flat top of the stump and touching the fallen trunk with my right hand, I said in the most dramatic tone I could master, "See! I touch the tree. If there are really any evil spirits they are all gone into me!" A low murmur of disapproval ran round the ring of onlookers and the overseer said dismally, "They say that you are Tuan and therefore different. There will have to be a blood sacrifice performed upon that stump before we shall get any more work done here." So, when I had ascertained from him that the matter was truly serious and not a gigantic hoax, I instructed him to tell the men that there would be a blood sacrifice which should free us all of the curse which the felling of this tree had set upon our heads. Calling, therefore, for two representatives to attend upon me to arrange details, I strode away to my little office in what I hoped was an appropriately dignified manner, but not without a haunting fear that I might be, after all, the victim of a first-class Tamil joke.

Presently they came, an ill-assorted couple, the one, long and lanky in a striped loincloth, barefoot, and the other, short and stout, with a scarlet turban, ragged white vest and khaki shorts, and an ancient pair of plimsolls. Their first demands were fantastic. It was now Thursday, and "nothing could be done about the sacrifice before Sunday. In the interval no work would be done." But it was firmly and not too politely intimated to these delegates that there was a limit beyond which the leg, even of an inexperienced Tuan could not be extended and that, if they would not work, the whole labour force would be dismissed forthwith and new coolies taken on from the ample resources of the local labour market. Whatever ceremony they required to perform must be done that day and any man who failed to report for work on the day following would be discharged without further question.

The delegates prevaricated. Did not the Tuan realize that the services of a Holy Man would be required, and sacrifice, and that these things could not be arranged at a moment's notice? It might just be possible to arrange the ceremony for to-morrow evening

which would only involve one day's loss of work. But the Tuan was adamant. Enough time had been wasted already over this preposterous affair. There would be no more work that day but to-morrow the "Tuan Majesty's" works must go forward unhindered. The delegates withdrew to confer, and returned in due course shamefacedly to bring to the Tuan's notice that it would be necessary for some funds to be made available to provide the requisite sacrifice.

Not without some misgivings, I enquired just what was required for this ceremony, and, duly counting off each item on his long, bony fingers, Loincloth enumerated a chicken and a coconut and a banana and a betelnut. After some further confabulation behind the scenes, it was Shorts who, nervously shooting his eyes into every corner of the room, announced that they considered that the sum of one dollar* would be adequate to enable the affair to be carried through satisfactorily.

Now one dollar seemed to me a modest enough sum of money to secure the peace of mind of over a hundred souls, so I duly rifled the Office Cleaning Allowance and discharged the "Tuan Majesty's" debt to superstition with as much ceremony as the circumstances permitted, adding a futile warning that there were to be no more "sacred" trees. And thus it happened that a noisy, perspiring rabble deposited their tools forthwith in the adjacent store and departed to arrange for their own salvation, leaving me with a receipt for one dollar defaced by Shorts with a spidery cross, which was even now being certified as his mark by a flabbergasted Indian timekeeper.

The exorcisement took place that evening and by the time they had finished their service, and had duly slaughtered the hen and sprinkled the stump with its blood and had offered the coconut and the banana and the betelnut, it was dark. And with that sudden falling of the night which is characteristic of the East, they built them a fire and roasted the fowl, turning it upon a pointed stake. Then, together with other things which they had brought with them, they devoured the sacrifice and at ten o'clock, with a young red moon leering at them from the arms of Canopus, they betook them in little silent knots to their homes. And at six-thirty the following morning the "Tuan Majesty's" works were resumed as though there had been no interruption.

And there the matter might have rested if I had never met the railway engineer and told him of the episode. All the railway engineer said was, "You were darned lucky to get away with a chicken. Why! When we were on construction in Kelantan we were constantly meeting '*pokok hantu*' and it generally meant a goat, if not a calf!"

* 2s. 4d.

And so saying he devoted himself once more to a close inspection of the work of his gang of Chinese platelayers who, to the accompaniment of a monotonous rythmic chanting, were slowly levering a length of track on to the correct alignment. But later, the thought came suddenly to me that in an area such as this, which had been thickly peopled with Chinese, it was not improbable that there would be further sacred trees and that no solemn warning issued over the cash-box could prevent us from meeting them. And, as the Office Cleaning Allowance was totally inadequate to pay repeatedly for chickens and betelnuts, let alone for a goat or a calf, I resolved to attempt to establish the precedent that Government should pay directly for clearing its ground, not only of Chinese and their pigs and their dogs, but of their evil spirits also. So out came the receipt for one dollar, while a long-suffering Finance Clerk duly prepared the papropriate forms and inscribed a long letter to the Paymaster setting forth the circumstances in which this sum had been expended.

The Paymaster, or his assistant, must have been gifted with a sense of humour rarely met with in financial departments. Or it may only have been a more than usually rigid compliance with the regulations for his branch of the service which caused him to address a letter to the Padre, requesting him to certify that the exorcising of the evil spirits could not have been carried out by himself and that the amount claimed was, in his opinion, reasonable.

In due course the Padre replied that there was nothing in his experience which might be regarded as conferring upon him the power to exorcise the evil guardian spirits of a Chinese sacred tree, and that he had searched his textbooks in vain for a reference to this subject. As to the amount claimed, he had ascertained from his wife that the current market rates for the chicken, the coconut and the banana might amount to fifty cents. The betelnut could be acquired gratis anywhere, and the remaining sum of fifty cents was not only not excessive for the services of the priest but, in his view, totally inadequate.

The Paymaster, armed with this certificate and finding no fault with the making out of the Claim Forms, retained the scrawled receipt of Shorts and put his signature to a draft for one dollar in the appropriate space upon which his clerk had inserted the words :— " Services in connection with exorcisement of evil spirits consequent upon the felling of a sacred tree. Provision of sacrifice—50 cts. Services of priest—50 cts." And so, in due course, the amount was repaid to the Office Cleaning Allowance.

But The Tree lay where it had fallen and was not removed for firewood by the Chinese like the rest of the felled timber. And, at last, when the site came to be required for building purposes, The

Tree was sawn into lengths and carried to one side, where it lies to this day. And the fires which successfully disposed of the roots of other trees would not burn at the stump of the "*pokok kramat*", so that it had finally to be dug out and buried in a great hole made specially for it. We had no more sacred trees. Perhaps it is because there was no three days' holiday; or maybe there was barely enough chicken to go round at the feast. These things must be considerably easier in Kelantan, where it generally means a goat or a calf.

But perhaps, as my host said that day off Pulau Ubin, there is something in it after all.

CORRESPONDENCE.

TRAINING OF R.E. OFFICERS.

The War Office,
Whitehall, S.W.1.
16th December, 1938.

To the Editor, *The Royal Engineers Journal.*

DEAR SIR,

At the beginning of his letter published in your issue of December, 1938, Captain Bourne remarks on a "notable contrast." May I draw attention to another?

At the end of his letter Captain Bourne agrees with a previous writer on the subject that "works service cannot be classed as training for war." *Audi alteram partem.* On page 577 of the *same* issue, Major Davey, writing of Ideal Field Company Training, concludes his article with the remark that he strongly recommends this form of training (a works job) to the other field companies at home.

I forbear to rub it in farther as Colonel King's article on "Works Services and Engineer Training" in the *same* issue does so very effectively.

Yours faithfully,
A.G.B.B.

Kirkee,
January 14th, 1939.

To the Editor, *The Royal Engineers Journal.*

DEAR SIR,

The time-honoured controversy over the war-training value of experience in Engineer Services has again raised its head and the contents of *The R.E. Journal* for December, 1938, provide plenty of food for thought on the subject, notably General Bond's address to the R.U.S.I. ("The Military Engineer in Modern Warfare").

It is idle to generalize on the direct value of Engineer Services

for training officers in their duties in war. The conditions of employment and type of work undertaken, for example, in a division on the N.W. Frontier of India differ entirely from those in a garrison in the U.K., though it is admitted that organization of work, to some extent, is a common factor in all cases. Moreover, whatever its value, such employment has certain economic and administrative advantages for the British Army, the conditions of which cannot be compared directly to those in Continental armies. The question is, therefore, how can it be turned to best advantage in preparing officers for their duties in war.

Before the question can be answered, we must be quite clear as to what is required of R.E. officers in war. It will presumably be agreed that their primary role is that of a field engineer or field unit officer. Now it is to be regretted that Colonel King's "Works Services and Engineer Training," in analysing the officers' task, glossed over the "operations" head, for on this depends whether the energies and resources of the engineers are used to their fullest advantage. This is really the crux of the whole question.

General Bond made good use of his opportunity to emphasize the necessity for commanders to realize fully the engineer problem and to study how they can best be used to help in achieving the military object. But the task of commanders is becoming more and more complicated and they must rely more on the immediate and reliable advice of their technical advisers, whether they be Chief Engineers or field company subalterns, according to the size of the force. To be able to give such advice, a technical adviser must

(*a*) Have an intimate knowledge of the possibilities of his own weapons—that is to say, any engineer resources which can, by hook or by crook, be put at his disposal.

(*b*) Be able to appreciate the military situation sufficiently well to apply the use of his weapons to further the attainment of the object.

In other words, he must try to be several steps ahead. If he is not, he will not be able to obtain and organize the necessary labour, plant, material and transport in time. He must not wait for orders. He must foresee them and, sometimes, be prepared radically to influence the plan. If, by omission to give timely and definite advice to his commander, an opportunity of victory is lost or disaster is threatened, he will have to bear the responsibility. However good he may be at actually organizing or designing work, the labours of his troops may be wasted if he is unable to apply his technical knowledge to a rapidly changing military situation.

It is unnecessary here to mention the difficulties of obtaining realistic opportunities to practise this in peace. We are at a great disadvantage compared with other technical arms in this respect.

But we can go some way in answering our question about the comparative value of Engineer Services and field unit experience. An officer with plenty of field unit experience should at least know a good deal about requirement (*a*) if he has been able to use imagination in training himself and his unit. The works officer, according to the local conditions of his employment, may be more accustomed to organize work, thus cancelling a certain rustiness in knowledge of the detail of unit equipment and handling military labour. It is in requirement (*b*) that so many fail. But here the field unit officer has at least better opportunities of keeping touch and being in the right atmosphere. On balance, then, one would say that he *should* be able to take his place more usefully in war as a military engineer.

There is no space here to discuss the possible remedies. They vary from insistence on more technical-tactical exercises (which owing to the pressure of the daily round are too often given lip service only) to changes in organization and conditions of employment. It is largely a matter of priority, of what is recognized as the primary call on the time and energies of the officer. But I do suggest that changing frequently the employment of officers merely serves to defeat its own object.

Yours faithfully,
C. DE L. GAUSSEN, *Lt.-Col., R.E.*

Headquarters, China Command,
Hong Kong.
January 20th, 1939.

To the Editor, *The Royal Engineers Journal.*

DEAR SIR,

With reference to Capt. Bourne's letter of October 26th, 1938, on the subject of the " Training of Royal Engineer Officers."

Some time ago a fairly well-known civilian engineer, on talking of this, said, " You in your training attempt the impossible, but, by God, you get it." The attainment of the impossible seems good enough, so why not let well alone ?

Everyone, however, at some time or other wants to reorganize either the whole or bits of the Army and each of us has the right to his own opinions on the subject, and if we do not agree we need not quarrel about it.

There is one statement, however, in Capt. Bourne's letter which has nothing to do with reorganization. He states, " That the personal contact between all ranks is so much better in other arms of the Service than in the Corps of Royal Engineers."

This gives a completely false picture of the relations between R.E. officers and their men, and I feel that it should be contradicted.

Yours faithfully,

G. C. GOWLLAND, *Colonel.*

London.
January 27th, 1939.

To the Editor, *The Royal Engineers Journal.*

DEAR SIR,

In his letter published in your last issue Capt. Bourne seems to advocate the division of the Corps into "Works" and "Field" branches. Whatever the merits of such an organization may be, it is not that laid down in the Manuals. I think the basic problem, after the Engineer requirements of the Division have been met, is that of producing senior officers who, firstly, can gain the confidence of those civilian engineers who must be employed in war, and, secondly, can satisfactorily direct higher engineer policy in the field.

The production of an *ad hoc* military works or engineer organization on mobilization may be possible in totalitarian and conscript countries but would lead to great delay and confusion with us. It is quite certain that, at any rate at the outset of a campaign, engineer work must be controlled by regular engineer officers. The primary need, however, is that those officers should be "trained engineers" as well as "trained soldiers."

If the engineering profession were asked to define a "trained engineer," the answer would be—a man qualified under the following heads :—

(*a*) Academic training in school and university.
(*b*) Practical drawing office experience in design.
(*c*) Practical experience on the "works."

Civilian engineers regard anyone not properly qualified in these three ways as an amateur.

R.E. officers now have a perfectly satisfactory academic training, but they get no proper drawing office experience and it is generally admitted that the majority have insufficient experience on the works.

The only way to get Drawing Office experience is to go into a drawing office and draw, and this should be arranged. A year would be none too long.

As regards experience on the works, if a man is not a trained engineer by the age of 30 he never will be one. According to the last *Quarterly List*, about one-third of the captains and subalterns under this age are employed in non-engineering appointments. An officer

finishes with Cambridge and Chatham at about 23, so he has seven years in which to learn his trade. This is reduced to about five years by reason of non-engineering employment. Deduct one year for drawing office training and four are left for experience on the works. If this period was spent looking after "large contracts," as recommended by Colonel King in his article, all might be well. But how many "large contracts" are there for junior officers to look after? The question cannot be burked by regarding the whitewashing of barracks as engineering experience. Further, some of the four years must be spent in field units, but there should be no delusion that the handling of standard equipment affords useful engineering experience. Clearly, the R.E. officer has to learn other things besides engineering and, because the quality of the works experience available is so limited, his post-graduate training ought to be most carefully organized and controlled. It is to be feared that the young officer is too often regarded as a "trained engineer" when he finishes with Chatham and Cambridge, and this, as I have tried to point out, is very far from being the case.

Intensified training is required and the best form of intensified training is for an officer to be allowed to handle labour, stores and transport without the intermediary of a contractor.

I was C.R.E., Lancashire Area, at the time the Eastriggs job was carried out and can confirm Major Davey's remarks in your last issue.

If there were an inviolate rule that *every* junior officer had to spend a year at a drawing-board, followed by four or five years in or on civil works, or in direct charge of labour, etc., on selected military work, there might be a little organizational difficulty and some extra expense, but we should at least get trained engineers.

I am,

Yours faithfully,

H. S. BRIGGS, *Lt.-Col.*

SOIL STABILIZATION AT LYDD.

Norman House,
105–109, Strand, W.C.2.
12th December, 1938.

To the Editor, *The Royal Engineers Journal.*

DEAR SIR,

When I got my commission, a Gunner uncle, writing to congratulate me, observed that Sappers are reputed to be mad, married, or Methodist; "personally," he added, "I advise a judicious sprinkling of all three." Lieut.-Colonel Behrens says that he is an engineer, not a chemist; but surely he will claim to have such a sprinkling of chemistry as will enable him to appreciate the value of

the information lacking in his article on the work on the South Brooks track at Lydd. The article gives the sieve analysis of the original soil, but omits to say the amount of clay added during the operation, and the ultimate grading provided. This is information which, though it would be furnished by the chemist, is essential to the engineer.

It is in order to assist Lieut.-Colonel Behrens' object of interesting R.E. officers to get further similar work carried out that I ventured to write asking for this information, on which constructive criticism could be based. My letter criticized the excessive quantity of diluting water used, and the wrong description of the work as "soil stabilization," which Lieut.-Colonel Behrens admits. But the proportion of clay added and the ultimate grading are essential facts which we should have if useful suggestions are to be offered.

My firm specializes in soil stabilization, and in all work on which we have co-operated with officers of the Corps it has been our practice to give full details of analysis, etc., to enable the report to be complete and of help to any further similar work; such a report comes appropriately from the R.E. officer responsible, rather than from the co-operating firm.

Yours faithfully,
E. G. WACE,
Brig.-General (Retired).

CAMOUFLAGE IN NATURE AND IN WAR.

Ordnance Survey Office,
Southampton.
February 10th, 1939.

To the Editor, *The Royal Engineers Journal.*

SIR,

While reading the article "Camouflage in Nature and in War" in *The Royal Engineers Journal* of December, 1938, I was surprised to find that the author makes no reference to the effect of relief—or stereoscopic effect—which a solid body will give to a being with two eyes. I am not referring, of course, to the optical illusion of relief given by shadows—an illusion which, as Dr. Cott has shown, is cleverly counteracted in nature.

The examples of natural camouflage given in the article are remarkable—but they are only fully successful against the one-eyed. A stereoscopic pair of photographs of the larva of Fig. 6, if examined in a stereoscope, would so cause the creature to stand out from his carefully chosen background that it would never occur to the observer that there had been any attempt at camouflage. Moreover, the light markings running diagonally across the animal's back are so well defined that, under a stereoscope, they would show up the

cylindrical form of his body at once. These remarks would, I am sure, apply to all the examples and perhaps more particularly to Figs. 8, 11 and 14.

The principles enunciated by Dr. Cott will apply in war only to the one-eyed observer, who may be typified by the observer in an aircraft. Since the limit of stereoscopic effect has, optimistically, been put at 200 yards for naked-eye vision, the air observer may be considered to be, in this sense, one-eyed. This short range of 200 yards is due to the small distance, $2\frac{1}{4}$ inches, which separates the human eyes. The air camera is not so limited. It is a simple matter to take two photographs of the same area of country from air stations many hundreds of yards apart. When examined in a stereoscope, these pictures will show up the relief of the ground—and of small objects on the ground—in a most remarkable manner. With suitable pictures, taken from as high as 10,000 feet, it has been found possible to measure the heights of objects to within one foot. The mere detection of their shape is considerably easier.

Disruptive painting, which is, rightly, considered to be of importance in camouflage against the single eye, can actually be of the greatest assistance to the stereoscope. The patterns of Figs. 9, 10, 12 and 13 are just what the stereoscope wants. The stereoscope will discover the real shape of a solid object and the disruptive camouflage may even help it to do so. It is of little value to pretend to change the shape by paint.

I wonder if *Uroplates fimbriatus* and *Xanthopan morgani* know this. They try to turn themselves into low mounds gradually sloping down to the background—not perhaps only to avoid throwing shadows.

To deceive the stereoscope, the object must either be buried underground or provided with a protection covering a large area and which can be fashioned to represent the natural relief of the ground. Both methods may be too elaborate in practice and the best way to succeed might possibly be bluff rather than camouflage.

It is notorious that a man needs much experience before he can interpret even common objects correctly on a single photograph. With the aid of the stereoscope, even the beginner has no difficulty in correctly recognizing, by their shape in three dimensions, objects which on one picture appear as unrecognizable blemishes.

It follows that it should be a never-to-be-forgotten rule that, firstly, when photography is carried out for the detection of camouflage, the pictures should be taken so that any part of the area is covered by a pair of photographs and that, secondly, the pairs should be examined in a stereoscope and preferably in one with a magnification of about 5X.

Yours faithfully,

E. H. Thompson, *Captain, R.E.*

All Reviews of Books on military subjects are included in the provisions of K.R. 535c (*1935*).

BOOKS.

(Most of the books reviewed may be seen in the R.E. Corps Library, Horse Guards, Whitehall, S.W.1.)

THE OFFICIAL HISTORY OF THE GREAT WAR.

MILITARY OPERATIONS. FRANCE AND BELGIUM, 1916. 2ND JULY, 1916, TO THE END OF THE BATTLES OF THE SOMME.
COMPILED BY CAPTAIN WILFRED MILES

(Macmillan and Co. Price Text 12s. 6d. Maps 10s.)

This volume of the Official History (which for some unexplained reason is not given a number) concludes the account of the battles of the Somme begun in its predecessor, "1916," Vol. I.

With the exception of Chapter V—which gives an account of the unfortunate subsidiary attack at Fromelles, 19th/20th July, and Chapter XX—which includes a brief summary of trench warfare activity on other parts of the front during the last half of the year, and an explanation of the situation which led to the appointment of Sir Eric Geddes as Director of Transportation—the volume is exclusively devoted to tracing the course of the Somme offensive from the conclusion of the first day's fighting to the end of the struggle in a November snowstorm.

Chapter XX also contains a brief account of the Chantilly Conference which, when the offensive was drawing to a close, outlined the future strategic plans of the Allies for 1917. A fuller account of the Conference in its political setting is promised in "1917," Vol. I.

A recapitulation of the many tasks of the Royal Engineers behind the front, which are not referred to in the main narrative, will be found too in Chapter XX.

What we get from the volume is chiefly a detailed and wonderfully full account of the infantry struggle and of the part played by tanks when they appeared. It is something of a miracle that it has been possible to piece together so clear a picture, even with the aid of the German and French Histories now available, and of the personal recollections of the great number of combatant officers to whom the draft narrative was submitted. The narrative is essentially non-controversial; and criticisms of individuals, from the Commander-in-Chief downwards, are conspicuous by their absence. Failures are described as frankly as successes; but, though the reasons for failure are given, blame is not fastened on to individuals or units. Those who delight in chasing scapegoats will be disappointed.

I confess that before embarking on the narrative I read first the final chapter of "retrospect," as well as General Edmond's preface, and I would recommend other readers to do the same, for, to form a fair judgment, it is essential to have a true picture of the conditions under which the battle was fought. In the retrospect chapter, for instance, we are reminded of the technical developments which increased offensive power in subsequent years—developments which gave greater scope for varying method, for achieving surprise and for doing more effectively what was

attempted on the Somme. It was not only tanks which came to the assistance of the infantry. The 106 fuze, smoke shell, gas shell and survey methods all played a part in neutralising hostile artillery and in reducing the advantages that wire and machine guns gave the defence. Those who are inclined to criticize the conduct of the Somme battle must keep in mind the limitations of the instruments employed. That mistakes were made, no one would deny. Opportunities were on occasion lost of achieving more, either through excessive caution or through too rigid adherence to programme. Useless sacrifice of life and added confusion were also sometimes caused by attempts to redeem failure under impossible conditions and without proper preparation. For instance, more boldness in exploiting success on 3rd July might have secured a hold on Mametz Wood and other localities, whose capture in subsequent fighting was to cost so much. Similarly, it is possible that, if the highly successful dawn attack of 14th July had been exploited with the fresh troops at hand, a position including High Wood and the neighbouring ridge might have been secured. If these opportunities really existed, we certainly paid dearly for the neglect to seize them. There can, I think, be little doubt that the battle of Loos had caused a tendency to over caution in exploiting success; because its failures were at first more commonly attributed to a too ambitious plan, rather than to defective handling of reserves. Even in the Somme battle, there are indications that reserves were at times placed far in rear, and that little attempt was made to move them forward in anticipation that they might be called on. In consequence, on the occasions they were required to sustain the momentum of attack, they arrived late and exhausted after what, owing to the nature of the ground, was a long march—The History suggests that more liberty to exploit success might with advantage have been delegated to the commanders of lower formations. On the other hand, commanders of leading formations appear to have been over-anxious to retrieve failure by desperate measures.

It is generally conceded that many of the minor operations, undertaken to secure more favourable conditions for major attacks in preparation, were unnecessary, and resulted too often in heavy casualties and exhaustion of troops and ammunition. Although they undoubtedly inflicted loss on the enemy and tended to lower his morale, they do not appear to have interfered seriously with his organization of new defensive lines. Before condemning them, however, in the light of experience of the last years of the war, it is well to remember the factors which, in those years, made preliminary operations less necessary.

What we chiefly want to know is how far a battle of attrition, as the Somme became, contributed to the ultimate result of the war. It has, of course, been argued that the attack suffered more in the process of attrition than the defence, and that therefore the result of the offensive was rather to delay, than to contribute to, ultimate victory.

General Edmonds in his preface analyses the losses experienced by both sides and arrives at the conclusion that, numerically, they were surprisingly even. The moral gain was, however, with the attack and the German losses of highly trained officers and men were irreplaceable. It is true that the British, too, lost much of its finest fighting material, but the survivors had acquired experience which went far to compensate for their previous lack of training. That the Somme offensive was far from achieving all that was hoped for, must be admitted, but that it may fairly be reckoned a notable contribution to ultimate victory is some consolation for the sacrifices it entailed. That it might perhaps have achieved more if no mistakes had been made, is certainly insufficient reason for pursuing with vindictive abuse those who were human enough to fall into error on occasions.

Whether the record gives a guide to students as to what can or cannot be achieved by an offensive in modern war, may be questioned. It does, however, testify to the persistent efforts soldiers of the Empire will make under the worst conditions—and conditions in the later stages of the Somme were as bad as those of Passchendaele.

This new volume, if from the nature of the fighting not light reading, maintains the

high standard of its predecessors; and the maps, both the sketch maps bound with the text, and those on a larger scale contained in the small volume of appendices, admirably illustrate the narrative.

C.W.G.

HISTORY OF THE GREAT WAR.

ORDER OF BATTLE OF DIVISIONS.

Part 3 A. *New Army Divisions* (9–26).

Compiled by Major A. F. BECKE, by direction of the Historical Section, Committee of Imperial Defence.

(H.M. Stationery Office. Price 12s. 0d.)

This is the fourth volume of the series and contains the order of battle of the first 18 New Army divisions, all of which went overseas in 1915. It follows the lines of the previous volumes, with one interesting addition; the battle casualties of each division are given. A table giving these figures for all British Divisions is promised in the next volume; but, for the 18 divisions recorded in the present volume, it is interesting to compare the 14 which served on the Western Front with the four who served only in the East. The battle casualties for the former averaged 40,074, including those of the 23rd Division (23,574) which was in Italy throughout 1918; this average may be taken as two and a half times the War Establishment; and in the 18th (Eastern) Division, where the number of actual deaths is also recorded, the percentage of deaths was 30. The battle casualties of the latter four divisions averaged 9,442.

E.V.B.

LES FORTS DE MOULAINVILLE ET DE DOUAUMONT SOUS LES 420.

By LIEUTENANT R. MÉNAGER.

(Paris. Payot. 18 francs.)

This contains a good deal of interesting information with reference to the resistance of the Verdun forts. It is mainly about Fort Moulainville, Douaumont is only touched on after its recapture by the French. The author was commander of the artillery at the two forts in turn. Commandant Harispe, who was in command of them, gives the book his good wishes and contributes a letter. His official report is printed in the book.

Fort Moulainville has received little mention in history. It was situated due east of the town of Verdun, three miles south of Fort Vaux. It was never taken by the Germans, but it suffered most terrific bombardments.

Built in 1885, but later modernized, it was a lunette in trace, with deep revetted ditches, flanked by caponiers and counter-scarp galleries. The central mass of concrete, covered with "a thick layer" of earth, contained two large casemates opening on to the inner court, which in time of peace served as barracks. On the flanks, two other casemates served as ante-chambers to the lower stories, which contained the headquarters office, the telephone exchange, magazines, sleeping accommodation and hospital. From these ante-chambers, passages and staircases led to the cupolas, expense magazines and ditch defences. The water tanks were covered only by earth, and the supply pipes were but one metre under the soil; a shell burst in the main tank and destroyed it, so water had to be carried up by hand.

One cupola contained a 6-inch gun; another, two 75-mm. field guns, with armoured O.P. There were also, besides the ditch defences (12 guns), two pairs of machine-guns mounted in small cupolas.

The concrete, 1·30 metre thick (the Germans had found 1·50 desirable), was reinforced, except over the galleries. Both the commandant and artillery commander of Fort Moulainville consider that plain concrete behaved better under heavy shell-fire than ferro-concrete. An extract from Commandant Harispe's report, written in July, 1916, will be quoted. It would appear that the concrete was far from first class. The report runs:

"The reinforced concrete of Moulainville is so divided into little compartments by "the steel rods, which reinforce its mass, that a violent shock pulverizes it: the rods "are exposed, and the stone and cement separate. It is evident that reinforced "concrete is more fragile than ordinary concrete; the latter breaks up into very "large blocks which remain in equilibrium and support each other."

"It should be mentioned that at Moulainville the steel rods are laid in horizontal "sheets; there are no vertical connecting rods. The result is that where the reinforced "concrete has not flowed away like water, it *is divided into strata like a layered* "cake. The layers, separated by the metal network, have not made a homogeneous "whole."

Between March 25th and July 9th, the fort was struck by 339 shells of 16-in., 220 of 12-in. and 10-in., 4,720 of 4-in. and over 130,000 smaller calibres. No other fort received half this number of 16-in. shells. A series of photographs show the result: the top surface is a mass of craters, the inner court and ditches filled up; but, as at Douaumont and Vaux, the lower tier casemates were untouched. The gun cupolas were not hit and the guns were still in action at the end of nine months; but the passages leading to them were often blocked. The lesson seems to be that big howitzers cannot hit small targets.

The first mishap was due to an order having been given by the higher command to prepare the fort for demolition. Charges were laid and connected by detonating fuse; the fuse was hit and in consequence one counter-scarp gallery destroyed. The other charges were then disconnected.

The effect of the explosion of the 16-in. howitzers greatly shook the nerves of the garrison; a few men, including the doctor, became insane. On April 10th permission was given for the bulk of the garrison to leave the fort at night. Later, shallow trenches were dug outside, in which the garrison took refuge during bombardments. A certain time was available to take cover, as the look-out men could see the flash of the 16-in. and the shells did not fall until 63 seconds afterwards.

In November, after the French victory and recapture of Fort Douaumont, Fort Moulainville was safe from assault. The author with his artillery detachment was transferred to Fort Douaumont. He mentions that its reinforced concrete was "*plus solide*"; it had suffered less and its central mass was better preserved. It is well known that the only damage done to the two tiers of casemates was by an interior explosion of rifle grenades and flame-thrower oil. Douaumont was not seriously shelled after the date of its recapture.

J.E.E.

THE ARMY.

By Brigadier R. H. DEWING, D.S.O., M.C.

(London: William Hodge and Co., Ltd. Price 2s. 6d.)

The Army is the third volume in this publisher's *National Defence* series—a companion to *The Royal Air Force* and *The Navy*. The object of the series is to explain the working, scope and limitations of the various services to the "average citizen" who helps to pay for them.

In *The Army* the author deals with the development of the land forces of the Empire and with the roles of the Army—home defence, the defence of bases, Imperial policing and the provision of an Imperial reserve. He discusses the

remodelling of the Army (including, of course, the Territorial Army), the re-equipment and modernization of the various arms and the consequent modifications in organization and training. Finally, he reminds the reader that Imperial Defence is not a matter for one service only, but for all three—to say nothing of the civil organizations.

The usefulness of this little book need not be restricted to the "average citizen." Officers in particular are likely to welcome such a concise presentation of the Army's problems, not merely for its value for examination purposes, but more because the author takes things as they are and not as they might be in quite different circumstances. He deals with facts, not with fancies; he is out neither to praise nor to condemn. Consequently, the book is of definite value in helping one to assess the good and the weak points in some of the more sensational and provocative articles that appear from time to time.

I.S.O.P.

IMPERIAL DEFENCE—A PROBLEM IN FOUR DIMENSIONS.

By Major-General H. ROWAN ROBINSON, C.B.

(Frederick Muller. Price 10s. 6d.)

Imperial Defence covers such a vast field that it is necessary, in selecting material for a book on the subject, to make up one's mind for whom one is writing. Otherwise, there is a danger of the man in the street being overwhelmed in technicalities, or the expert being unsatisfied with generalities. We cannot feel, in this case, that the author has sufficiently considered his public, but from the last page, and other indications, we gather that the book is intended to rouse an interest in the subject amongst the general public.

As the sub-title indicates, this is a study of the problem in four dimensions, the fourth dimension being "time." We could welcome a little more attention being devoted to this "fourth" dimension, but are glad that consideration is also given to the moral or ideological side, which might almost be considered a "fifth" dimension.

The first part of the book is devoted to a study of the more familiar problems of warfare in two dimensions, that is, without the complications of air and submarine forces. Part Two is devoted to "strategy" (elastic term) in three dimensions. Part Three deals with the Home Front, economic and industrial problems, and air raids precautions. Part Four, entitled "Some Problems of Imperial Defence" devotes its first chapter to "the Army," since "the Navy and Air Force occupy so much of the Press and literature that there is a tendency to forget the Army." Other chapters in this Part are devoted to Palestine, the Mediterranean, India, the Far East and Australia. Finally, Part Five sums up.

It is difficult to deal adequately with a book of such range, and covering so much detail, in a short review. It is possible only to touch on some of the points discussed, and if, as is natural, most of those points are such that the reviewer must be critical, it must not be assumed that the majority of the book is not carefully and soundly argued.

In the two-dimensional Part Two, the problems are not so novel, but the author's views on the tactics of Armoured Fighting Vehicles are worthy of study, and approximate to the very latest thought on the subject in this and other countries.

Later, however, on more contentious ground, one senses a tendency to present a one-sided argument, and a spirit of intolerance with those who think differently. This is particularly noticeable in the author's unmeasured attack on those responsible for naval policy for their alleged failure to move with the times, particularly on the question of the Capital Ship. The bias in presentation of a case is well illustrated by the statement of the Palestine problem (page 283), which leans heavily towards the Arab side.

Such prejudice should warn readers to consider the bases of the arguments presented before accepting the conclusions.

The Sapper will do well to note (page 82), the stress laid by the author on the importance of the "strategy of demolitions" both in preparation and repair.

The author swells the chorus of those who would have a Ministry of Defence. He suggests, however, that one of the sub-ministries should be that for A.R.P., and that this should organize and administer A.A. Defence (page 220). The impracticability of this is obvious when one considers, in the first place, that the first line of A.A. Defence is the aeroplane, which from the nature of its range and mobility cannot be earmarked solely for one purpose. In the second place, aircraft and the A.A. Units on the ground are dependent on military equipment, bombs, machine guns and spare parts, and require military personnel for their training. A similar apparent lack of appreciation of the problem of A.A. Defence leads to the suggestion (page 216) that A.A. Defences should be manned by the personnel of works to be protected. This can be, and is, done in the case of light guns to meet low-flying attack or dive bombing. But for the main defence from the ground, against high-flying attack, guns must be placed, not to protect individual installations, but to co-operate with aircraft to meet attacking aircraft well in front of major targets. Searchlights must be scattered over a wide net-work to produce a fighting zone for our aircraft and to illuminate the attacking aircraft as they approach the gun lines.

With regard to the Territorial Army, the writer, in spite of the pledges to the contrary, and our existing systems of producing reserves otherwise, considers that the personnel will be used as reserves for the Regular Army. He suggests that increased reserves for the Regular Army should be found by a combination of long and short service. These being found, he recommends, except for Home Defence, we should maintain no Territorial Force except in cadre form (page 272). Later, he agrees that T.A. Divisions might be wanted in the East at four and a half months' notice (page 303). Knowing that a cadre can do little or no training and the Kitchener Army Division in the Great War required about six months' training for even trench warfare, the arguments appear to be contradictory.

In spite of matters open to criticism, such as have been commented on, the author has produced a readable and informative thesis on the subject of Imperial Defence. The informed reader will find food for thought in the theories propounded, and the less informed public may be induced to take more interest in a subject of vital importance to themselves and the Empire.

R.P.P-W.

HISTORY OF THE BOMBAY PIONEERS.

By Lieut.-Colonel W. B. P. Tugwell.

(The Sidney Press, Ltd., London and Bedford. Price 10s. 6d.)

The title of this book is a little erroneous for the old Bombay Pioneers, destined, like their successors to be disbanded and absorbed into the Sappers and Miners, are not even mentioned.

The story of second incarnation of the Bombay Pioneers must, however, be of great interest to those R.E. officers who have served in the Bombay Sappers and Miners, with whom they maintained a strong *liaison* and who are again their residuary legatees. The Sikh Pioneers, on their disbandment in 1932, had their Corps History written by an eminent military author; the Bombay Pioneers have confided theirs to one of their own officers. The latter has produced a book which is a real history of the Corps and of the greatest interest.

The Bombay Pioneers originated from five regiments:—the Marine Battalion (the Marines of the old Indian Navy), the 4th Battalion (later 7th Regiment) of Bombay Sepoys, the 3rd Regiment of Infantry, Shah Shuja's Force (later 12th

Bengal Infantry) all of which became Pioneers in 1903; the 28th Bombay Infantry, who became Pioneers in 1888, and the 48th Pioneers, raised as such in 1901. They are probably best known to R.E. officers by their pre-war numbers of 121st, 107th, 12th, 128th and 48th.

The story of the three Bombay regiments is practically that of the Bombay Army and of the old Indian Navy. The Marine Battalion had naturally a most varied career and actually fought against the Americans in 1815, the 107th was a sound regiment and the 128th had a high reputation both as Pioneers and fighters. The 12th, the Kelat-I-Ghilzaie Regiment, earned its title in the field, and the 48th, the last raised, won great distinction in Mesopotamia. It is enough to say that when combined into one corps, they had more battle honours than any unit in the Indian Army except the Sappers and Miners, though most of the infantry regiments were also an amalgamation of five or more battalions.

The five battalions and some second line battalions were merged into the 2nd Bombay Pioneers (three active and one training battalion) in 1922, and into the Corps of Bombay Pioneers in 1929. They were disbanded in 1932, owing to financial stringency.

The book is particularly satisfactory because Colonel Tugwell records fully not only their fighting but their work, giving each its due weight, and so furnishes an excellent account of the work of Indian Pioneer battalions in war. They did a great variety of technical work well, and, when called on to fight as infantry, could fight well. It was not until after the war, when infantry armament and training became more complicated, that the fulfilling of both roles became difficult.

Colonel Tugwell has done his work well; enough general history of each campaign is given to make the story of the units comprehensible, without, as often happens in such books, swamping it. The more domestic details are grouped in appendices at the end. Altogether, a most successful regimental history.

There is an introduction by Field-Marshal Sir Claude Jacob, himself a Pioneer officer, in which he deplores the disappearance of the Pioneers. Many Sappers will agree with him; but how came he to state that prior to 1888 the Bombay Army had no Pioneer units? The fact that 1888 saw not the birth but the revival of the Bombay Pioneers gives additional force to his argument.

E.V.B.

LORD ROBERTS.

By Lieut.-Colonel H. DE WATTEVILLE, C.B.E.

(Blackie & Son. Price 5s.)

This book is one of the Order of Merit series of popular biographies of members of that Order, and Lord Roberts is the first soldier to be included. To compress the story of a singularly eventful life of 82 years within 168 octavo pages must have been very difficult, and much has been curtailed; for instance, only a very short account is given of Lord Roberts' efforts, after his departure from the War Office, to induce his countrymen to prepare for the Great War, which he knew was impending. The book, however, must be looked upon as a biographical study, not as a political or military treatise, and as such is an adequate popular summary of the field-marshal's career as a fighting soldier, as a commander in the field and as a military administrator.

There are a few slips; the fanatics, who established themselves at Sitana, and gave so much trouble in 1863 (p. 58), were not Hindus; and it is a matter of some surprise that in such a short biography, an appendix of two pages should be given to a description of the Blowing-in of the Cashmere Gate, with which Lord Roberts was in no way concerned.

E.V.B.

PRINCIPLES OF MODERN BUILDING.

Vol. I. Walls, Partitions and Chimneys.

By R. Fitzmaurice, B.Sc., A.M.Inst.C.E., Building Research Station.

(H.M. Stationery Office. Price, 10s. 6d.)

For nearly two decades the Building Research Station of Garston, Herts, has been carrying out researches on building problems and investigating failures in buildings which have been submitted to them by architects and builders. A tremendous amount of information and experience has thus been acquired, and upon the joint request of the Royal Institute of British Architects and the Chartered Surveyors' Institution a start has been made to record it.

The work was entrusted to Mr. R. Fitzmaurice, B.Sc., A.M.Inst.C.E., who has had a long experience in building; in teaching building construction; and in research work at the Building Research Station. The author has succeeded in presenting a large amount of information in an easy style. He has had the help of an influential committee, headed by Sir Raymond Unwin, LL.D., D.Tech., D.Arch., F.R.I.B.A.—in deciding the scope, contents, methods of presentation and general form of the work.

The book is well printed on good paper and contains some 400 pages; heavy type has been employed to emphasize the more important information.

There are 100 tables and drawings and many beautiful photographs splendidly reproduced. The photographs have been specially selected to illustrate various common external wall finishes and their weathering value under differing conditions of atmospheric pollution.

This volume has chapters on the function of walls; solid load-bearing walls; load-bearing cavity walls; non-load-bearing members; monolithic reinforced concrete; surface finishes for external walls; special structural features; damp walls and mortars.

The structural features dealt with are those of perennial interest to all concerned with building. They include points to be watched on damp-proof courses, parapets, cornices, chimney stacks, flues and fireplaces, to avoid the common mistakes which lead to dampness and smoky chimneys.

The book is not merely a repetition of information to be found in ordinary building textbooks. It is assumed that the reader is already well grounded in normal building methods, and the author aims at enunciating the fundamental principles to be observed in order that materials may be used to their best advantage. This is especially important at the present time, owing to the large number of new materials and methods which have been introduced.

These innovations have not all proved to be successful and the book will provide an answer as to the cause of failure in many of these cases.

Information is given on the correct mortar to use with different classes of bricks; how much sound and heat insulation is necessary under given circumstances; the factors which lead to the formation of shrinkage cracks and how they can be controlled; the properties of walling materials and suggestions as to the design of walls from the point of view of rain exclusion; the causes of efflorescence in brickwork and suggestions of means to avoid this unsightly phenomenon. The foregoing are merely a few examples taken at random to indicate the wide variety of problems dealt with. At the end of the discussion on each problem, practical recommendations are summarized in heavy type.

The present volume is to be followed by other volumes on Floors, Roofs and Structural Framework; Foundations and Works below Ground Level; Internal Finishes and Decorations; and a couple of further volumes on more specialized subjects. It is hoped that they may be issued at intervals of not greater than a year.

W.B.C.

THE AIR AND ITS MYSTERIES.

By C. M. BOTLEY, F.R.MET.S.

(G. Bell & Sons, Ltd. 6, Portugal Street, W.C.2. Price 8s. 6d. net.)

Under duress of modern conditions, civilized folk are rapidly resolving themselves into two classes, meteorologists and meteorologically-minded laymen. Miss Botley's book of twelve easy chapters is directed mainly to the latter class, though under encouragement of Sir Richard Gregory's foreword the reviewer opines that it will be read with pleasure, and with profit too, by meteorologists—professional and amateur—the world over. As has often been noted in connection with her many contributions to the literature of the Royal Meteorological Society, the author possesses in rare measure the gift of lucid explanation; so much so that a reader, starting from zero, is held from the start, and finishes up, if not knowing "more than his masters," at least with a first-rate *nodding* acquaintance with what is at once the most difficult and most fascinating of all the sciences. The book might well have as sub-title "Meteorology without Tears." There is not a mathematical formula to be found in all its twelve chapters.

Apart from the close connection between the Meteorological Service and The Corps in the European war, points of contact being so many, the subject should have peculiar interest for Royal Engineers, and the reviewer confidently recommends to his brother officers the reading of Miss Botley's book as a delightful holiday task, if nothing more.

T.C.S.

THE CRADLE OF THE NORTH WIND.

By Captain A. S. T. GODFREY (late R.E.).

(Methuen. Price 8s. 6d.)

Besides giving a very plausible answer to the vexed question of why people go exploring, the preface contains a warning that the book is "... a personal and egotistical account" of the expedition by one already initiated to the Arctic and with "... no great stake in the enterprise."

The narrative which follows bears this out. The reader is not burdened by facts and figures relating to the sciences which were investigated so efficiently; but rather delighted and entertained by a tale of adventure, in which moments of triumph and exasperation, hope and disappointment, follow hard on one another against a vivid background of Arctic scenery and animal life.

The journey to North-East Land and the preparations for the winter are lightly and wittily sketched, but between the lines one can glimpse the back-breaking work which such a sortie against nature must entail. Here is inserted a short but interesting history of previous efforts to endure the country, which makes sad reading.

A chapter is devoted to first-hand impressions of the country's sole industry—trapping; with descriptions of methods and details of costs and profits.

The physical and mental discomforts of the imprisonment imposed by the long Arctic winter are hidden by accounts of the happier incidents, amusing extracts from diaries and frank statements of the thoughts, feelings and reactions of one of two individuals completely isolated for two months in the darkness of a tent buried beneath the snow. Incidentally, the author and his companion remained firm friends even after their return to civilization.

The spring twilight of February brought release and revealed the strain of such a winter on the author's physique and constitution.

Throughout the following spring and summer the reader is carried across the island on long and not uneventful sledge journeys, or watches birds, polar bears and seals on the coast.

Finally, as if not satisfied by twelve months' adventure, monotony of diet and cold, the author journeys even farther north through the pack ice on a Norwegian sealer before returning to England.

H.C.S.

A GUIDE TO THE OLD TESTAMENT.

By Lieut.-Colonel E. N. Mozley, D.S.O.

(S.C.M. Press. Price 3s. 6d. pp. xvi + 139. *Second Review.*)

No reviewer can write in an entirely objective spirit and it may be suggested that the criticism of this book which appeared in *The R.E. Journal* for December, 1938, is somewhat heavily coloured by the writer's own opinions. It may, therefore, be thought desirable that there should be available another review, written from a different angle, and the Editor has kindly permitted the publication of this second review of the same book.

Colonel Mozley's book has the great advantage of commencing with a commendatory "Foreword" by the Headmaster of Winchester, who remarks, "We have lived through the days when learning and criticism were looked upon as the enemies of religion." Indeed, the application of the criticism of scholars and the discoveries of archæology have combined to render that library of ancient writings, which we call the Old Testament, of greatly increased value to educated men who take an interest in history, and particularly that branch of history which deals with the development of religious ideas. It is the principal achievement of the Hebrews that they evolved, from a primitive tribal religion, the great ideas of ethical monotheism. Of the four important religions now in existence, three are directly traceable to Hebrew thought.

Colonel Mozley justly remarks that, "The broadcasting of knowledge naturally lags behind its acquisition. In the case of knowledge about the origin, historicity and comparative morality of the books comprising the Old Testament, it is not to be wondered at that this lag is increased through a natural enough fear of doing harm to the trust which Christian people should put in their sacred writings. But in the long run more harm always comes from withholding truth than from announcing it." This is well said, and the book is written with this excellent precept in mind.

The plan of the work is, briefly: a short note on Our Debt to Israel; then a short chapter on Modern Views on the Old Testament; followed by Historical and Geographical Notes. Then the books are taken, in order, and after an introduction in each case, the contents are dealt with chapter by chapter by means of short textual notes, in which the leading results of scholarship are drawn upon. The non-specialist reader will find much to interest him, and the school teacher will find the book of real value in guiding the young to an honest appreciation of this ancient and most educative literature. There is no attempt to force an acquiescence in its fabulous and legendary elements.

In the next edition, without materially increasing the bulk of the book, the author might, perhaps, draw more attention to the discoveries of archæology. Thus, the Tell-el-Amarna letters and the inscribed stones of Beth-shan throw some light upon the Egyptian domination of Palestine during the obscure period of Joshua-Judges. The siege of Jericho is illustrated by Professor Garstang's excavations, and incidentally we learn that it was but a little city of some 1,500 inhabitants. Warren's shaft in the hill of Ophel is the clue to the capture of Jerusalem by Joab. And so on. Such external evidence will sometimes add to the vividness of the ancient records. In other instances it will enable us to correct our views as to the course of history, and it will always give us a valuable background. But the book under review is excellent as it stands and is to be heartily welcomed.

C.F.A-C.

COMMONSENSE AND A.R.P.

By Major-General C. H. FOULKES, C.B., C.M.G., D.S.O.

(C. Arthur Pearson, Ltd. Price, 1s.)

This little book is described as a Practical Guide for Householders and Business Managers. It is an attempt to extract, from the large number of official handbooks, circulars and memoranda, what the ordinary man needs to know and do; and to advise him how to do it. General Foulkes aims firstly at putting Passive Air Defence in its proper perspective. The real protection against air attack is active defence and the certainty of reprisals; these demand the lion's share of our resources, and what is available for passive defence should be concentrated on the protection of objectives, the destruction of which would seriously affect our military strength. Under these circumstances, a certain amount of risk must be taken rather than cripple vital defence. General Foulkes shows that the comparative small number of casualites in Barcelona have not been due to the deep shelters, which could only hold a small fraction of the population; and he goes thoroughly into what can be done cheaply to give protection against everything except the comparatively remote danger of a direct hit by a heavy bomb. The advice is principally concerned with the factory and large city block, and deals with organization as well as structural precautions, but what the smaller independent householder requires is easily found. General Foulkes' opinions on the danger of gas attacks have, of course, a special value.

The book should be of the utmost value to everyone who has to organize passive air defence as a private individual or as an employer.

E.V.B.

MAGAZINES.

CIVIL ENGINEERING MAGAZINES.

The following articles which have recently appeared are recommended as being of special interest to Royal Engineers.

Publication.	*Date of Issue.*	*Article.*
Civil Engineering.	November, 1938.	"Oldham Sewage Works." This gives a clear and interesting account of how a very common problem is dealt with at Oldham *i.e.*, the extension of an existing sewage works to deal with an increased flow. In this case the method of partial treatment by the activated sludge process has been adopted.
The Structural Engineer.	December, 1938.	"The Road as a Structure." An interesting article in which the author traces the evolution of the modern road, points out the impossibility of a standard specification on account of subsoil variations, and discusses the fundamentals of the design of concrete roads.
Excerpt *Journal of the Institution of Civil Engineers.*	Paper No. 5203.	"The Conditions of Engineering Contracts." A general comprehensive survey of the whole subject of Engineering Contracts is given in this paper. The author deals very clearly with all the documents of a contract and with many important legal aspects involved in certain conditions.

THE MILITARY ENGINEER.

(*November–December*, 1938.)—*Use of Triangulation.* William Bowie.

A short article on the various uses of triangulation and the stage triangulation has reached in the U.S.A.

Engineers in Chemical Warfare. W. F. Heavey.

A consideration of how the use of chemical agents in future wars will influence certain engineering operations, particularly in so far as concerns developments since the World War.

The question of water supply contamination is considered, also whether it is quicker to delay reconstruction of a demolished bridge until a thorough decontamination has been accomplished, or whether it will be more expeditious to abandon the site and build on an alternative one. The use of smoke to cover river crossings is discussed.

Since "combat" engineers in emergencies fight as infantry, it is important for

them to be familiar with the principles of chemical warfare in so far as they affect the infantry. The engineer in the next war must be gas conscious.

The article is couched in very general terms.

Strategic Mineral Supplies in Central Europe. G. A. Roush.

An outspoken study of the intentions of Germany in Europe as regards expansion, with particular reference to her mineral requirements. The article was written after the "anschluss" but before the crisis in Czechoslovakia; it is interesting to note how accurate the writer's prophecies have proved to be with regard to Germany's intentions concerning territories in Central Europe. He tabulates the mineral resources of various European countries and makes clear the intentions of Germany with regard to making up for her own considerable mineral deficiencies; he also shows her surplus group of minerals.

Fort Belvoir Intensifies Reserve Summer Training. Horace W. Pote.

A short report on an engineer camp for the training of Reserve Officers.

The Signal Corps School.

In the year 1938–39 the student body of the officers' department numbered 46, who were trained in electricity and magnetism, wire telephony and telegraphy, radio telegraphy and telephony, field radio communication, field wire communication, training methods, tactics, combat and signal orders, message centres and military cryptography, field exercises, international morse code and radio procedure, signal supply, preparation of efficiency reports, and defence against chemical warfare.

Approximately 150 men graduate yearly also. Methods of instruction and the School's accomplishments are stated.

Photogrammetric Methods and Equipment. Louis J. Rumaggi.

A discussion of the principles utilized in the automatic plotting machines which are now in vogue in the preparation of topographic maps.

Reflections on Reservist Training. Henry A. Finch.

The writer, in running reservist training in America, has clearly suffered from the same troubles as those who have to run such camps in this country. He deals with such troubles as lack of Regular Army personnel to assist him, lack of equipment and facilities, lack of time (a fortnight's training a year), and ground that has been used time and time again. The writer goes on to show, given time and the persuasive powers, how these troubles may be overcome, even if pontoon equipment has to be taken 2,000 miles by lorry.

Some principles and hints on instructing reserve officers are discussed and such remarks as "lectures, being the least efficient of all forms of instruction, should not be used at summer training camps" provoke interest.

A suggested programme of training for a fortnight concludes the article.

E.S.B.

REVUE MILITAIRE SUISSE.

(*October*, 1938.)—*Du combat offensif.* By Lt.-Col. Montfort.

In spite of their numerical inferiority, the author urges on the Swiss an offensive policy whenever the opportunity presents itself. The Swiss, he says, have limited offensive possibilities, but they do exist. There will be occasions when the enemy advances too boldly, and he must be attacked. The principles of the official regulations are elaborated in a series of paragraphs clearly expressed.

L'Exercise du commandement en temps de paix. By Lt.-Col. E. Mayer.

The peace-time training of the soldier depends largely, but not entirely, on the development of discipline. Wide variations in the interpretation of the word discipline

are permissible. But nobody has yet discovered a unit doing well in the field which was slovenly conducted in barracks. The system of constant inspections by superior officers is seldom anything but superficial. The author describes the system of training in a French battery with which he served some fifty years ago. His captain made all his "specialists" interchangeable. This had no apparent effect on parade, but at practice camps it produced good results, and in war it would have been invaluable. There is scarcely time, in the present short-service conditions, for the employment of such a system; but it has less defects than the "cramming" method of rehearsing the same actors. Understudies are often required; and there is no doubt that a uniform high level in a unit is better than a patchwork affair.

Colonel Mayer would like to see inspectors go behind the scenes more frequently. The better the officers and N.C.O's know their men, the better will be the command of the unit.

Les mesures militaires prises par la France à l'occasion de l'Affaire Louis-Napoleon (1838). By J.-C. Biaudet.

In 1838, Louis-Napoleon Bonaparte, who had failed in a *coup-de-main* against Louis-Philippe in 1836, was a refugee in Switzerland, and the French Government were anxious that he should leave. The Swiss claimed that he was a Swiss citizen and could not therefore be expelled. The French collected a heterogeneous force from the southern garrisons and moved it against the Swiss frontier. The Swiss responded by collecting a similar force. Relations became strained and strong proclamations were issued, but Louis-Napoleon left Switzerland in the end, and no hostilities occurred.

A detailed account is given of the composition of the forces on both sides.

(*November*, 1938.)—*Principes de fortification permanente*. By Col. Moccetti.

An interesting article (continued in the December issue), of which it is hoped to publish a full excerpt in the June issue of *The R.E. Journal*.

Nation et Armée. By Lt.-Col. E. Mayer. Practically a review of Colonel Gaulle's *La France et son armée*, recently published in Paris, which traces the evolution of the national character of the French Army, especially since the Revolution of 1789.

Quelques considérations sur la discipline et l'initiative. By Capt. Schlegel.

It is much more difficult to obtain strict obedience to orders to-day than formerly, when troops fought in solid ranks and phalanges. But obedience to orders is not the only form of discipline required. A frame of mind which carries the spirit of obedience, initiative, courage and confidence is the necessity for to-day. The intellectual standard in a voluntary army will always be higher than that of a conscript force, but the better understanding of discipline in the former does not follow. Liberty is sometimes confused with laxity.

The author gives three illustrated examples from the Great War—one German, one French and one Austrian—in which the initiative of junior commanders had a decisive effect upon the operations in which they were engaged.

(*December*, 1938.)—*Le combat sous bois*. By Colonel Junod.

Considering the amount of wooded country which abounds in Europe, the subjects of fighting in woods is peculiarly neglected. Even Switzerland has 20 per cent of its area covered with forest. In Poland and Russia the proportion runs to 60 per cent.

The author finds that there is a marked aversion to introducing the subject into training programmes, except in France and Germany, where it is systematically practised. In the days of close order, woods were avoided, as they broke up the serried line of battle and complicated the business of command. But to-day, they can play an important part, either as screens from air observation, or as obstacles to motorized weapons; and their attack or defence will therefore play some part in the general conflict.

Colonel Junod, an infantry instructor, gives a full summary of the principles of wood-fighting adapted to modern conditions.

W.H.K.

REVUE DU GÉNIE MILITAIRE.

(*Sept.-Oct.*, 1938.)—*La motorisation et la mécanisation des unités du Génie dans l'armée allemande.* By Captain K.

This instalment deals with the probable employment of motorized engineers, and is based on an article by Captain Meltzer in the *Pioneer Quarterly* for November, 1935. The German author's deductions are stated to be that, in the future mechanized warfare, mobile engineer units will have to operate far afield, on the flanks or even in the rear of the enemy, and that they must not expect close support or assistance. They must therefore be self-supporting, and have their own anti-aircraft and anti-tank resources. They must practise dispersal and camouflage. They must in fact be little independent bodies. But how, it may be asked, can they do all this and still carry out their tasks?

Destruction and obstruction, it seems, will be the role of the engineers as often as construction and clearance. The time may soon come when all this heavily-armoured mechanization will defeat its own end, and, like the armoured knights of old, find itself out-matched by more nimble, lightly equipped troops.

Examples of the employment of such mechanized engineers are given, taken from the same German author's article in the *Pioneer Quarterly* for February, 1936. These examples are illustrated with maps.

Le Pont de Bosserville (exécuté par le 1er Regiment du Génie). By Lieut. Escande.

An account of a new bridge built over the Meurthe by the 1st Engineer Regiment in 1937, to replace an old wooden structure which existed before the war. The task was given to the army engineers in order to keep down the cost. It was a timber pile bridge, some 350 feet long, to carry 9 tons. The detachment of sappers consisted of 84 all ranks, with a working strength of 54. The whole work took 26 days of 8 hours. The cost to the State was 15,000 frcs. and to the commune 120,000 frcs.; something less than £800.

Note sur les coffrages pour les travaux de béton. By Captain Dardonville. Deals with the method of obtaining smooth surfaces on concrete structures without additional coatings, by using shuttering specially treated. The timber is well planed on both sides, and saturated in boiling oil. The oil drained from motor-car sumps is quite suitable for this, and has the advantage of cheapness. The latter factor is of some importance, as the extra cost of the preparation of the timber is considerable.

Étude sur l'équilibre des câbles chargés verticalement. By Captain Maillet. A study in three chapters of the formulæ for cables in suspension.

W.H.K.

REVUE MILITAIRE GÉNÉRALE.

(*October*, 1938.)—*Les leçons d'une cité.* By General Gamelin.

The centenary of Marshal Mouton, Count Lobau, was the occasion of an address by General Gamelin at Phalsburg, Lorraine, in which he sketched the history of this little town. Several celebrated soldiers of France belonged to Phalsburg, notably, Lobau, Gérard, Charles Michelet—whose two sons were also famous in the last war, one as Commander of the Fifth Army, and the other of the V Corps—Logerot, a former Minister of War, Hollander, Gerboin, Faure and Hotz. Of these, Lobau was the only one to become a Marshal of France.

La République Argentine, et l'Armée Argentine. By Colonel von der Becke.

The author is director of the Higher War College of Argentina. He gives a brief account of the Republic, its population, natural features, economic wealth, and its army. The population is composed of a multitude of races, chiefly Italian and Spanish. This fact seems to explain the revolutionary tendencies of the past.

The army, built up on traditions less than a century and a half old, is based on obligatory military service, and the diversity of its national elements might possibly be regarded as a source of weakness, in the event of any external conflict.

The article describes the army's constitution rather than its organization, and no account is given of its strength, but it is imbued with a progressive spirit, and is continually gaining in solidarity.

Le bombardement aérien et les principes de l'organisation industrielle. By Camille Rougeron.

The author draws attention to the vital importance of dispersing industries, especially armament industries, to minimize the effect of aerial bombardment. Little has so far been done in this direction, and, considering the necessity of maintaining in war-time the output of arms and munitions, the author urges that much more attention should be paid to the problem. No part of France or of Germany is now out of range of possible bombardment. The great factories are grouped together in vulnerable fashion, and in easily accessible directions. Complete dislocation of work could be brought about in a raid of short duration. In Russia, the manufacture of such vital parts as ball bearings is concentrated in a single factory in Moscow. In France, nine-tenths of the production of aeroplane engines is concentrated in Paris.

Not only is dispersion necessary, but protection as well. Work must not cease, or the national war effort will be subject to delays or interruptions which might be fatal. The countries subject to aerial bombardment must therefore reorganize their industries—a task so vast that it might well be the deciding factor in abolishing aerial warfare.

La Cavalerie dans la guerre d'Espagne. By General Niessel.

So much has been written of the mechanical side of warfare in Spain that the use, or even the existence of cavalry, has been overlooked. General Niessel has gathered an account of the employment of cavalry in the Spanish war from an article by a Russian officer in the *Krasneia Zviezda*. Most of the ten cavalry regiments in Spain at the beginning of the rebellion went over to the Nationalist side. Part of them were transferred to the other arms, but six regiments were formed into a regular division, while the Moroccan squadrons provided a separate brigade under Colonel Monasterio. These units also included a proportion of motorized infantry. On the Government side, there were only a few hastily raised cavalry units.

The action of the cavalry is chiefly confined to pursuit, or the holding of posts and villages from which the defenders have been driven, until the arrival of infantry. A number of instances have occurred of minor engagements of the cavalry, but the units have for the most part acted in small parties.

L'intervention de l'aviation dans la lutte terrestre. By General Maginel.

The employment of air units in the ground combat was too limited during the Great War to enable any useful conclusions to be drawn. There were no instances of it until the offensives of 1918, but the warfare in Spain has widened the experiences, and the author, a distinguished officer of the French air service, has made a strong claim that such air action in the future will play an important part in the decision on the ground.

He claims that very decisive effects may be obtained by the air bombardment of troops in action, of tank masses, or of motorized transport. He discusses the technical aspects of such flights, and leaves us with the impression that, given certain favourable conditions, the menace to troops in action will be a more serious factor than has yet been contemplated. Dispersion of tactical units—the natural answer to such a menace—has increasing disadvantages with large motorized bodies.

Essai sommaire sur les corps cuirassés. By Captain Grimaux.

The author is advocating a large mechanical formation—an army corps of tanks—ready to be sprung upon the battlefield, with air force in support. He believes that sudden action with such means would be more decisive and less costly than an overwhelming heavy artillery; and he gives comparative costs of these two alternatives, showing how much more expensive a modern heavy bombardment by

artillery can be than an attack by tanks. Certainly, the latter method does not destroy the ground and make it impassable for other arms.

(*November*, 1938.)—*Études stratégiques. Manœvre sur idées préconçues et surprise stratégique*. By General Brossé.

A fresh study of the failures of the French strategy during the battles of the frontiers, in August, 1914. The importance of studying military history, not by tabulating events in a time-table or by marking troops on a map, but by deducing the lessons of the strategical and tactical movements, is emphasized in an editorial foreword by General Azan.

The article deals clearly with the outstanding events of August, 1914, on the French frontier, and points out how the preconceived plans and notions of the Higher Command came to grief, and why they did so.

The premature advance of the small Army of Alsace, on the extreme French right, to obtain the moral effect of recovering Alsace, only resulted in the capture of Mulhouse and the projection of the French right into a position difficult to hold; and gave a fresh instance of the failure of a strategy conducted for sentimental reasons. The liberation of Alsace would follow from the main decision, wherever obtained.

The principal French error was the failure of the High Command to realize the full extent of the sweep of the German right wing. Liège was expected to sustain a siege of several weeks at least, and the Belgian Army was considered to be in no great need of succour. Hence the feeble projection of Sordet's Cavalry Corps towards Belgium, the tardy advance of the Fifth Army to the Sambre and the dangerous exposure of the British Army on the extreme left.

The author gives us all the main violations of sound strategy indulged in by the High Command, but without omitting the points of view which presented themselves to the latter. This is indeed the true way of teaching military history; all the deductions permissible on after-reflection may be set out with justification, but the situation as it presented itself to those responsible for the decisions must also be faithfully stated.

La guerre sino-japonaise vue de l'arrière. By Gen. X.

A view of the military spirit of the Chinese population of Yunnanfou, some 1,200 miles behind the "front." The author, who holds an important military post in Indo-China, spent some time touring the province of Yunnan, to which he was no stranger, and he gives his impressions.

The spirit of the people is redoubtable. A general consolidation has taken place, and there is a firm belief that in the end China will wear out the Japanese. Of man-power, there is no lack, and the training of fresh divisions continues without interruption; although the contribution of the province, with some 12,000,000 inhabitants, had not yet exceeded 50,000 men. The equipment is poor and insufficient; the supply services are also deficient, and the medical services, despite a nucleus of well-trained doctors, are particularly primitive. But the spirit of the people is the main source of China's strength. If the Japanese can be exhausted in the long run, a tremendous revival of China may be expected. These Powers which keep this in mind and cultivate the fair treatment of the Chinese will reap a great reward.

La fortification permanente en Allemagne. By Lt.-Col. Montigny.

The article treats of the theory of permanent fortification, as represented by recent articles in the Press by Colonel Dittmar, Commandant of the new German School of Pioneers at Kaiserslautern, who bases his ideas on the modern French conceptions.

France has always led the way in fortification; and although the experiences of 1914 destroyed for a time all confidence in permanent works of defence, it was only because those works were not adapted to modern conditions. To-day the

French believe firmly in fortified regions, that is to say, large areas strengthened with works of concrete and steel suitably disposed in depth, and furnished with adequate communications with all sources of supply. The Germans, more adverse to tying themselves down to particular positions and more disposed to rely on movement and attack, have nevertheless, adopted French methods, and Hitler's recent Rhineland fortifications may be said to follow the principles formulated by the French.

L'intervention de l'aviation dans la lutte terrestre. (*Cas concret.*) By Gen. Maginel.

The author, who gave an article in the October number on this subject (*see page* 141) now gives us a concrete example. He takes the case of a group of three armies operating on a front between the Moselle and Namur, and allots each army a group of pursuit squadrons, and to the army group two "heavy divisions"—a total of 256 machines.

The article is chiefly of interest to airmen.

Les enseignements de la Guerre d'Espagne. De la destruction massive à l'alerte continue. By Camille Rougeron. A comparison between the effects of a concentrated aerial bombardment *en masse* and those of a continued series of such attacks, as indicated by the experiences in Spain.

The author decides that the latter will have the greater effect, for they multiply the expenditure of anti-aircraft munitions; they interrupt the production of war factories; they wear out the workers in the factories by disturbing their rest; and they do just as much damage to the nerves of the population as a massed attack.

But it cannot be said that the Spaniards have proved the truth of Douhet's theories of wholesale aerial destruction.

Liaison militaire franco-britannique. By Comdt. de l'Épine. A short article by an officer who has had considerable experience of liaison work with British forces. He emphasizes, as all foreign critics do, the air of superiority assumed by the average Englishman, and the reserve which, until it is broken through, makes it hard for the Frenchman to appreciate the English character. The passage from politeness to cordiality, and from cordiality to confidence, is often of long duration, but once established, it is difficult to disturb.

The vital importance of a close association between French and British officers should encourage a wider intimacy, for much now hangs on the *entente cordiale* of the two nations.

(*December*, 1938.) This is the last number of the *Revue Militaire Générale*. The Editor explains in a foreword that its brief revival (two years) has covered the period in which the co-ordination of the three services has been effectively brought about in the scheme of National Defence. A new official publication, emanating from the Secretariat of the National Defence, is referred to.

Camarades Tchecoslovaques. By Gen. Gouraud. A short reference to the exploits of the 1st Czecho-Slovakian Brigade in the Fourth French Army in October and November, 1918, and the commemoration thereof in the monument subsequently erected on the Aisne.

Chars, anti-chars et motorisation dans la guerre d'Espagne. By Gen. Niessel. A review of the principal lessons to be drawn from the Spanish civil war. These lessons have been enumerated in several previous articles, and also in many other publications. The chief deductions made by General Niessel are that the experiences of both sides in Spain have done nothing to controvert the lessons of 1914–18; and that, owing to lack of trained personnel and of material resources, it would not be safe to draw too rigid conclusions from either side.

The heavy losses suffered by the Italian motorized column at Guadalajara in March, 1937, discovered by the Government airmen, are referred to.

As regards tanks and anti-tanks, the author gives us much the same information as before. The lighter German and Italian tanks have not done so well as the heavier Russian type. The small tank is easily held up by trenches too wide for it to cross.

Bottles of petrol ignited against the tanks easily set fire to the petrol vapours within the machines, and fear of being burnt alive is a strong weapon against the crews.

Land mines are not extensively used, owing to the rocky nature of most of the ground, and to the wide extent of the battle fronts. Paucity of roads limits the amount of material that can be pushed forward.

Le conflit sino-japonais. By Comdt. Rudioff.

A review of the causes which led up to the present war, a comparison of the rival forces, and a short account of the results of the conflict up to date.

The Japanese, tied to the river and railway communications (principally the latter), find that their ever-extending lines of supply expose them to a heavy loss of men and material. The imposing victories of the well-equipped Japanese armies against the pathetically ill-furnished Chinese divisions are recognized, even in Japan, to be productive of no decision yet, and the determination of Chiang-Kai-Shek to carry on guerrilla warfare is increasing the anxiety in Japan.

Japan has hitherto declared that she only wishes for economic co-operation with a resuscitated China, but it is clear that, if she wins the war, she will oust every other Power from the trading advantages which they have hitherto enjoyed.

It is a war of aggression which Japan is waging, and she deserves the condemnation of the Powers who wish to see a restoration of China as an ordered nation enjoying free rights.

Appui de l'infanterie par l'artillerie. By Gen. Buchalet.

The whole duty of the artillery is to facilitate the task of the infantry in its conquest and consolidation of ground. General Buchalet sums up his views by the statement that the problem resolves itself into knowing how far decentralization of the divisional command should go. Is it feasible to get down as far as the allotment of guns to a battalion?

Coup d'oeuil sur la politique allemande de l'automobile. By Capt. Brissac. A résumé of Hitler's great programme of industrial recovery through the development of automobile production. The four-year plan, as regards the motor industry, has raised German production to the third place among the nations; it has developed the strongest producing plant; and it is now turning its attention to the production of the "people's car." The result is a Germany organized throughout for a motorized war. The State will have in its hand a standardized motor transport carefully adapted to all its war requirements.

L'Autogyre et son emploi. By Lieut. d'Ollone. A brief article in support of the autogyro.

W.H.K.

BULLETIN BELGE DES SCIENCES MILITAIRES.

(*October*, 1938.) *Inauguration du Monument National au Roi Albert érigé sur l'Yser par les Anciens Combattants.*

An account, in French and Flemish, of the memorial erected at Nieuport to the memory of King Albert, by the ex-service men of Belgium, and unveiled on July 24th, 1938, by King Leopold.

La Guerre de 1914–18, sur le front russe. Souvenirs de campagne d'un officier de l'armée imperiale russe. By Lieut. Jusret. Extracts from the war experiences of an artillery officer of the old Russian Army, Capt. Koukharevitch. The narrative begins with an account of the types composing the soldiers of the Tsarist régime. Koukharevitch mobilized on August 2nd, 1914, as a second-Lieutenant of the 1st Battery, belonging to the 3rd Chasseur Brigade, 12th Corps, and took part in the operations against Lemberg and in the Carpathians.

L'Education physique à l'Aviation. By Lieut. Evrard. The author, a medical

officer, remarks that flying is a sedentary occupation. It certainly calls for physical exertions of a kind different from the normal occupation. After general remarks on the kinds of strain which the airman undergoes and the physical standards required of him, the author gives a programme of exercises which he recommends. Much of it is common to the normal "keep fit" enthusiast, but there is also much that is soundly set down.

(*November*, 1938.) *La Guerre*, 1914–18, *sur le front russe. Souvenirs de campagne d'un officier de l'armiée imperiale russe.* (*Contd.*)

This instalment includes a vivid description of Capt. Koukharevitch's experiences between August 20th and 26th, 1914, when Russian fortunes were in the ascendant.

Le peloton d'eclaireurs regimentaires. By Lieut. Moyson. An illustrated study of the tactics of the regimental reconnaissance platoon which, in various forms, is now included in the French, German and Italian infantry units.

Commentaries sur l'aviation de chasse. By Major W. Coppens.

A lecture to officers of the Belgian Air Service by a distinguished pilot of 1914–18. Full of sound advice and reasoning. The essence of the author's observations is that the airman is more often saved by boldness than vanquished by anti-aircraft weapons. Moral superiority is of infinite value.

Le recrutement et la formation des officiers du service de santé dans les Armées. By Maj.-Gen. Comte Leman.

A general account of the formation and organization of the medical officers of the Belgian Army, written for the general reader.

(*December*, 1938.) *La Guerre*, 1914–18, *sur le front russe. Souvenirs de campagne d'un officier de l'armée russe.* (*Contd.*)

The narrative covers a portion of the siege of Przemyl, and the fighting in Galicia up to the Russian withdrawal from the Carpathians in May, 1915. A story of mud and bottomless roads.

Le Fonctionnement de l'observation à l'infanterie. By Lieuts. Hourman and Joachim. Notes on reconnaissance and observation made during two years on an instructional course.

Les précurseurs des Chars d'assaut. By Capt. de Grave.

A rapid review of the tank's predecessors, ranging from the days of Xenophon to the Great War, illustrated with several sketches.

Colonel Estienne, of the French Army, was the first to develop the heavily armoured "tank" of 1915–16, and his ideas were being worked out during the time that the British inventors were evolving their types. It was only in June, 1916, —shortly before the British made their premature exposure of their tanks—that the two Governments exchanged their plans.

The failure of the Germans to produce any similar reply is remarked, but in an appendix the author gives us five instances of the use of tanks on the German side during 1918.

Les origines du Groupement automobile interallié pendant la campagne, 1914–18. By Capt. Hartman.

Towards the end of the war, a huge reserve of motor transport was organized to meet the increasing demands of the continuous series of offensive blows which Marshal Foch planned. Unity of command brought about a real pooling of Allied resources on the Western front, and just as the fighting troops were intermingled, so their transport was to be shared, and just before the Armistice, a large pool of 24,000 lorries was arranged, of which the French and American Armies contributed 8,000 each, the British 7,000, the Belgians and Italians another 1,000. The object was to meet the transport and supply problems of a force of about 40 divisions, operating at a distance up to 40 to 45 miles from railheads.

W.H.K.

RASSEGNA DI CULTURA MILITARE.

(*October*, 1938.)—*Le possibilità agricole dell'Africa italiana.*

General Teruzzi gives a brief survey of the work done in Italian Africa for the development of agriculture. Twenty years ago Libya was described as a sandy waste. By 1937 there had been planted 1,800,000 olive trees, 1,500,000 almond trees and 31,000,000 vines. The amount of wheat grown increases year by year. In Tripolitania deep tube wells have been sunk, and numerous artesian wells have been drilled. A number of these have a discharge of 350 cubic metres per hour.

Età augustea. By General Corselli.

The 2,000th anniversary of the birth of the Emperor Augustus is being celebrated in Italy this year. This article gives the chief events of Roman history between the death of Julius Cæsar and the death of Augustus.

Cecoslovacchia.

This is the first of a series of articles on Czechoslovakia. It describes the origin of the republic and its establishment by the Versailles Treaty, the reasons for the French alliance and the Sudeten question. In the November and the December issues, the same writer describes the crisis of last September.

Sul montaggio dei ponti metallici scomponibili.

Captain Betocchi discusses the theory of steel girders with parallel flanges and interchangeable parts. The girders in question are considered as simply supported at the ends. The essentials of such girders are that there should be as few different kinds of elements as possible, that the parts should be interchangeable, and that the girders should be adaptable for varying spans.

The drawback to this type of girder is that only a few of the parts are doing their full share of work. The members subjected to the maximum stress are the diagonals near the centre of the bridge and the verticals near the supports. The suggestion made by the writer is to lengthen the girders at both ends by a couple of bays, and apply counter-weights to the brackets so formed. The shear diagram will remain the same, but the diagram of moments will show a reduction of the stresses in the members subjected to the greatest strain.

Anticarro.

Colonel Mancinelli quotes from the March number of the *Rivista di Fanteria*, that a French division has allotted to it 50 25-mm. and 6 75-mm. anti-tank guns, and a German division 75 37-mm. guns for the same purpose. The tendency is to increase the anti-tank armament in a French division.

In a future war between great powers it is probable that the tank unit will consist of a mass of 100 tanks, and that a division will be furnished with about 75 anti-tank guns in places where the nature of the ground makes the employment of massed tanks possible.

The writer discusses the use of anti-tank guns in mountainous country, and whether it would be justifiable to use an anti-tank gun as an infantry weapon. Apparently not, even if the expected tank attack does not materialize.

Field artillery should not be used against tanks. It should engage the enemy artillery, and, during a tank attack, fire on the infantry following up the latter; it should be employed in counter-battery work and put up a barrage against reinforcements. Anti-tank guns should open fire against tanks at a range of about 500 metres.

(*November*, 1938.)—*La battaglia d'Italia.*

An account of the battle of Vittorio Veneto (October 24th to November 4th, 1918).

La marcia su Roma. By Marshal de Bono.

A retrospect of the rise of the Fascist power, and an account of Mussolini's march on Rome in October, 1922.

Coloni in Libia.

Marshal Balbo describes the project for the intensive colonization of Libya by Italians. Land has been allotted to Italian colonists since 1933. In 1938 colonization was conducted on a large scale: preparations were made in advance for the expected

immigrants by constructing roads, building houses, and sinking artesian wells. Some of the land is partly irrigated, some is cultivated dry.

On completion of the present project, the number of Italians in the country will amount to 140,000. It will go on increasing year by year until saturation point is reached.

Marshal Balbo refers to the Arab question. The Arabs, being entirely a pastoral people, regard their flocks and herds as their capital, and do not wish for land in exchange for that from which they have been dispossessed.

Esploratori e colonizzatori sulle vie dell'Impero. Sapeto, Doria, Gestro. By Marshal Graziani.

This article and another in the December issue describes the work of two great Italian explorers, Guiseppe Sapeto and Marchese Doria.

Studi di strategia sulla guerra mondiale. (Il piano austriaco.) By General Ago.

The Austrian strategic plan in the World War was profoundly influenced, not only by military considerations, but by political factors, both internal and external. There were two certain enemies: Serbia and Russia. The Serbian position was aggravated by the annexation, in 1908, of Bosnia and Herzegovina. Rumania and Bulgaria were uncertain factors.

As a member of the Triple Alliance, Italy was bound to help Austria in a defensive war only. The feeling between the two countries had never been friendly.

The frontiers of Austria to the south-west, south and south-east were favourable from a military point of view, and she was in a strong position as regards Italy and Rumania. On the Russian side her frontier was open, with only two important fortresses: Cracow and Przemysl. From a purely military point of view the correct strategy would have been an immediate attack on Russia.

To carry this out, Austria required the support of Germany. But the German Headquarter Staff did not see fit to change the rigid plan they had worked out for a crushing attack on France in the first instance, and Austria was obliged to conform to the German plan.

Il generale Cialdini e le artiglierie Cavalli all'assedio di Gaeta (1860–61). By General Caracciolo.

An account of the siege and capture of Gaeta by the Piedmontese in 1860.

Viabilità militare con particolare riguardo alle soprastrutture ed ai materiali leganti esclusivamente italiani.

In an introductory chapter, Captain d'Amico describes the difficulties encountered by the belligerent nations during the World War in maintaining their roads in a fit state to cope with the enormous expansion of traffic in the war areas. He deals with the various countries in turn: Italy, France, Britain (on the French front), Austria and Germany. Italy had made arrangements for getting her roads up to the requisite standard, but the war came before anything had been done.

The difficulties were similar in all the countries concerned; quite early in the war, roads became impassable owing to the terrific wear to which they were subjected, aggravated by mud in the winter and dust in the summer. In almost every case roads had to be entirely remade under constant and uninterrupted traffic. In 1917 the tarring of roads was begun and it solved the difficulties to a great extent. The Austrians saved their roads by using tramways for heavy traffic, and keeping the metalled surface for light traffic. The Germans were faced with a shortage of rubber, and their steel-tyred vehicles broke up the road surfaces badly.

Un metodo per la determinazione del potere occultante delle masse di nebbie e di fumi artificiali.

Dr. Ficai describes a series of experiments that have been carried out to determine the occulting power of smoke produced by various chemicals. It has been established that the density of smoke is increased by the presence of moisture in the air.

(December, 1938.)—Riflessi strategici della Grande Guerra.

Colonel Mattioli concludes an article begun in a previous number. Here he discusses

the value of a strategic reserve, and points out that in the initial German plan of campaign on the western front, no reserve had been provided. On the French side, the 4th Army held in reserve by Joffre did not place the latter in a position to turn events in his favour.

Another problem is the relative advantage of interior and exterior lines. The writer points out that the complete defeat of an enemy can only be accomplished by encircling him. The principle dates back to the battle of Cannae, upon which von Schlieffen's great turning movement was based.

Ludendorff.—*(Continuation and conclusion.)* By Prof. Folchi.

At the end of 1917, Ludendorff was making his preparations for the great spring offensive of the following year. The attack launched on the 5th British Army on March 21st, 1918, very nearly achieved the success that he had hoped for. Ludendorff has been criticized for either not remaining on the defensive on the western front, or, if an offensive was necessary—in view of the failure of the submarine campaign—for not throwing the whole of his reserves into the battle of Amiens.

On July 18th the tide turned definitely in favour of the Allies, and the possibility of a German victory vanished. With the armistice and the revolution in Germany, the only great soldier who took part in the new government was Hindenburg. Ludendorff vanished from the scene.

But history will always regard Ludendorff as a great strategist, and perhaps the most outstanding personality in the World War.

Considerazioni sull'impiego della fortificazione permanente. By General Cardona.

An interesting article on modern permanent fortification. Space only permits reference to a few of the points mentioned.

The value of fortifications will depend not only upon their fire, but upon the manœuvre and counter-attacks of mobile troops. On no account must defence be only passive, except as a means of gaining time.

Forts will be located so as to close a frontier at the main points of invasion, and at the ends of defiles and bridge-heads to facilitate the invasion of an enemy country. One of their objects is to ensure economy of force, and liberty of action and manœuvre for the field army.

The day of large forts is past: modern forts will be small, scattered, defiladed, and concealed. Their enormous cost will necessitate economy in their use. The intervals between them will be, to some extent, closed by lines of obstacles, but not so as completely to interfere with freedom of manœuvre.

The armament will be restricted to what is indispensable; there must be no attempt to engage the enemy's long-range artillery. It will be preferable to rely upon mobile batteries using high-angle fire, and upon aerial bombardment.

A good network of roads and railways is an indispensable adjunct to defence.

Viabilità militare con particolare riguardo alle soprastrutture ed ai materiali leganti esclusivamente italiani. By Captain d'Amico.

The roads in Italy that will be used by the army in war-time are almost entirely mountain roads. It has only recently been realized what an enormous saving can be effected in war-time if roads are properly aligned, graded and surfaced in time of peace. The writer calculates that every kilometre in good condition in war-time will set 30 men free for the fighting line.

He lays down the following conditions for a road that is to stand up to heavy traffic and varied weather conditions:—

(*a*) A suitable binding material (made entirely in Italy).

(*b*) Gradients not exceeding 7% in the straight and 5% in curves.

(*c*) A width of 6·60 metres (22 ft.) to take a line of heavy lorries going each way (or, better still, roads arranged for one-way traffic).

(*d*) Widening at curves.

(*e*) In sidelong ground, two-thirds to be in cutting, one-third in filling.

(*f*) Protection against avalanches and landslides.

A point to which considerable attention is being paid is the screening of roads from overhead view by planting trees alongside them.

Four kinds of surfacing are considered as suitable for replacing waterbound macadam :—

(1) Cement macadam (improved sandwich system).
(2) Macadam treated with silicate of soda.
(3) Surface treatment with powdered Italian asphaltic rock.
(4) Surface treatment with a mixture of tar and powdered asphaltic rock.

Then follows a specification of the "improved sandwich system" of cement macadam. Briefly, it amounts to :—

(1) Spreading a 10 cm. layer of stone ballast, in pieces 4 to 6 cm. in size.
(2) Rolling dry with a 12-ton roller.
(3) Spreading a layer of cement mortar (35 to 45 litres per sq. m.).
(4) Spreading a 5 cm. layer of stone ballast, 2 to 4·5 cm. in size.
(5) Rolling with a 6- to 8-ton tandem roller until the liquid mortar works up to the surface.
(6) Spreading another coat of cement mortar (10 litres per sq. m.).
(7) Spreading stone chips over the surface.
(8) Final rolling with tandem roller.

Longitudinal and transverse expansion joints are provided. The road must not be used for at least seven days.

A.S.H.

MILITÄRWISSENSCHAFTLICHE MITTEILUNGEN.

(*October*, 1938.)—*Review of Politics and Military Affairs in the Third Quarter of* 1938. By Major-General Paschek.

The Czechoslovakian question overshadows everything else during the quarter ending September 26th; the whole of Europe was never nearer a general conflagration. Credit is given to Britain for sending Lord Runciman to Prague as a mediator, and to Mr. Chamberlain for his visits to Berchtesgaden and Godesberg in the cause of peace.

Race and War. By Colonel Markgraf.

In the course of the war, Austrians had the opportunity of comparing the fighting qualities of the twelve nations of which the monarchy was composed. Napoleon would not have been successful in his wars against Germany if he had not had Germans fighting on his side. Now that a Greater Germany has been formed by the Führer's action, the spectacle of German fighting against German will never be seen again.

Lessons from the Spanish Civil War.

Lieut.-Field-Marshal von Gerabek quotes various authorities: American, French, German and Russian. A few of the points put forward may be mentioned here.

Air attacks, and especially bombing attacks, have had far less effect than was expected. Air defence could not effect a decision, but it succeeded in preventing panics. On the whole, defence predominated against attack, not only when passive, but in rear-guard actions. Motorized troops, unless able to move over any kind of country, were of little value. Small tanks did not justify themselves, their armour was insufficient. Anti-tank guns could hold up a tank attack if used in sufficient numbers, say, one to every 100 yards of front. Another authority, who considers the 2 cm. Oerlikon anti-tank gun to be the best of its kind, thinks that one such gun to every 250 metres will suffice. For anti-aircraft work the 2 cm. gun is good enough for the front line, where aeroplanes come down to a height of 1,000 metres; for back areas a more powerful gun is required of about 8·8 cm. (3·6 in.). Divisions should be as small as possible, to facilitate their handling.

Lorry-Driving in Mountainous Country.

Major Schmilauer gives details of a course of training on mountain roads for lorry-drivers working in convoy. The necessary skill can only be acquired by lengthy instruction and practice and strict discipline. For driving through snow, vehicles with caterpillar tracks are preferable both to those with wheels and compound vehicles.

Electro-optical Accessories for Observation in Fog and at Night. By Dr. Staeger.

During many weeks in the year visibility is restricted by haze, mist, or cloud. Infra-red photography has proved that long-wave infra-red rays will easily penetrate these obstacles. For military purposes an instrument is required that will allow of observation without the delay in developing films. Is it possible to devise an instrument that will convert heat rays into visible light?

In 1934, von Ardenne, of Berlin, applied for the patent of a specially-constructed cathode-ray tube. This idea has since been realized in a practical form by the *Allgemeine Electricitätsgesellschaft* and by the *Radio Corporation of America.*

The apparatus in question is described in this article, with the help of illustrations. The human eye only reacts to rays between red and violet, and everything is dark at night. But to the "picture converter" warm objects show up light and cold objects dark. Hence warm objects, such as steam locomotives, boilers and motor-cars, would show up on a dark night.

The Conflict in East Asia.

Major-General von Lerch here deals with the period July 20th to September 20th, 1938. He describes the Russo-Japanese incident at Changkufeng, the battle round Hankow and the guerrilla warfare in Hopei. A subsequent article in the December issue described the fall of Hankow and the operations leading to the capture of Canton.

(*November*, 1938.)—*From the Spring of* 1813 *to the Battle of the Nations at Leipzig.*

Dr. Czegda describes the events leading up to the battle of Leipzig and the battle itself.

The Four-Power Agreement at Munich.

Major-General Paschek discusses the political situation between September 27th and October 27th. There is, naturally, jubilation at the acquisition of Sudetenland, with some three million Germans and its rich mineral wealth and industries.

It is interesting to record the writer's point of view: The Western Powers were obliged to give in: they were not strong enough to do otherwise. Czechoslovakia, not directly supported by her allies, would very soon have been crushed. France, with very inadequate British support, would have had to face an overwhelming preponderance on land. Neither side was strong enough to win a decisive victory over the other in combined land, sea and air operations. Full mobilization, requiring months in Great Britain and the United States, would have been too late this time. The Western Powers had no faith in a timely Russian intervention through Poland and Rumania, nor in the holding together of the Little Entente. Britain was specially anxious about her communications with Asia and her key-position in the Mediterranean.

Fire and Movement. By Lieut.-Field-Marshal von Gerabek.

Some general principles on the connection between fire and movement are here enunciated.

Strategic Problems in the Mediterranean and the Near East.

Lieut.-Field-Marshal Schaefer traces the strategic value of the Mediterranean from the Punic wars onwards. Napoleon's attempt to secure complete control of it was thwarted by the British. From then onwards, British command of the Mediterranean was unquestioned throughout the whole of the nineteenth and the early part of the twentieth century.

Throughout the World War the Mediterranean was in the hands of the Entente, and France was able to draw unhindered on her African possessions for men and supplies. After the war, Britain and France secured a footing in Palestine and Syria,

the Turks were driven out of the Mosul oil-fields, and pipes were laid from these to the Mediterranean. Their late ally, Italy, had to be content with a few sandy stretches of African desert!

The Abyssinian War brought a new state of affairs to light. A war-like Italy had come into being. France was strong in the western Mediterranean only. Britain was caught unprepared, and found it necessary to withdraw her fleet from Malta, and concentrate her ships at Alexandria and Haifa, where she had neither docks nor means of repair, and was isolated, not only from Gibraltar and England, but also from her French allies.

The writer next discusses the problems of the present day. Britain relies, almost entirely, on her navy and air force. Maritime harbours are her main difficulty: Gibraltar and Malta cannot be extended, and have many disadvantages. It is a question whether sufficiently large harbours can be provided in Cyprus, Palestine or Egypt.

For France matters are simpler. Control of the western Mediterranean gives her access to her African possessions. The question of the construction of a canal connecting the Atlantic at Bordeaux with the Mediterranean at Narbonne has been revived. This would enable British ships to reach the Mediterranean without having to pass through the Straits of Gibraltar.

Italy is now in a strong position. With a huge army, a modern navy and a first-class air force, she controls the centre of the Mediterranean. By fortifying the island of Pantellaria she has reduced the width of the passage between Sicily and Libya to very narrow limits. Her action amounts to a threat to Britain not to interfere with the passage of Italian ships through the Suez Canal.

The Civil War in Spain. By Major-General von Lerch.

The account of the civil war is continued, and brings us up to October 20th, 1938. The Ebro salient is the main theatre of operations. The battle began on July 25th with the forcing of the river by the Red militia, and, so far, no decision has been arrived at. It is estimated that during the first five weeks an average of 10,000 bombs a day were dropped on the Ebro bridges. The damage done was hardly ever more than could be repaired during the following night.

Light Rays instead of Ammunition for Economical Target Practice.

Dr. Staeger explains the working of a combined camera and pistol or machine-gun by means of which an airman can test the accuracy of his aim on an aeroplane or other target. The instrument is made by the Williamson Manufacturing Co., Ltd., Lichfield Gardens, Willesden Green, N.W.10.

(*December*, 1938.)—*Ghazi Mustapha Kemal. A Memorial.*

A short account of the career of this distinguished Turkish leader.

Forty Years Ago. The Hague Peace Conferences. By Colonel von Hubka.

An account of the first international peace conference, convened in 1899 by the Czar of Russia; and of the second peace conference in 1909.

Finland, the Baltic, and Soviet Russia. By Dr. Sell.

In area, Finland ranks seventh amongst European states; she exceeds both Italy and Great Britain in size. But, with only 3·7 million inhabitants, she is only twentieth as regards population. Finland is on good terms with her western neighbours, Norway and Sweden, and there is little likelihood of a dispute with them. On the other hand, she would do well to count upon danger from Russia. Nature has, however, provided her with defences on her eastern border in the shape of lakes, forests and swamps.

Her main industry is timber, and Britain is her best customer. She takes her largest share of imports from Germany. Her towns and industries are all on the Gulf of Bothnia.

The writer discusses the possibilities of success that a sudden air attack from Russia might meet with. He concludes that such an attack would encounter a stubborn defence.

Infantry as an Expression of the War-like Spirit of the Masses. By Captain von Binzer.

The three most important elements in the training of the soldier are (1) patriotism, (2) *esprit de corps*, (3) confidence in his leaders. The writer elaborates this theme in his article.

Pill-boxes.

Lieut.-Field-Marshal von Gerabek describes some modern defensive constructions, which have come into prominence in the recent crisis.

The first are obstacles against tanks, called "Höckerhindernisse," and consist of concrete beams of different lengths, embedded vertically in the ground. In the British service they are known as "asparagus."

The second are curved concrete walls containing deep grooves, into which, at the last moment, rails or heavy baulks are let in, so as to hold up advancing tanks.

The third are "pill-boxes," known in Germany as "Bunker" (coal bunkers). They are, to all intents and purposes, immovable tanks made of concrete. In the World War, the Germans discriminated between British "female" and "male" tanks, according as they were armed with guns or machine-guns. A similar discrimination has been made between female and male Czech pill-boxes.

Pill-boxes can be given an all-round field of fire. By pivoting the gun in the loop-hole the opening can be reduced to a minimum. A direct hit from a 6-in. gun will not penetrate the concrete, though it may, in favourable circumstances, overturn the whole structure. The greatest danger is from the air, or by the very slow method of mining.

A.S.H.

VIERTELJAHRESHEFTE FÜR PIONIERE.

(*November*, 1938.)—*General Pullet.* By Lieut.-Colonel Grosse.

An account of the career of a distinguished Prussian Engineer officer. As a subaltern, Pullet was mainly responsible for the defences of Danzig when besieged by the French in 1807. Six years later, in 1813, as a Lieut.-Colonel, he was Engineer-in-chief of the Russo-Prussian corps that besieged and captured the same fortress.

125 Years Ago. Engineers and Fortresses in the Napoleonic Era.

Major-General Klingbeil describes the operations in the campaign of the Elbe between the end of the armistice on August 10th, 1813, and the decisive battle of Leipzig in mid-October. In these operations Napoleon failed to take full advantage of his central position, which should have enabled him to defeat each of the encircling armies of the Allies in detail.

The campaign did not call upon the engineers for any particularly noteworthy tasks. They had practically no regulation bridging equipment. It was not till the Silesian army crossed the Rhine early in 1814 that any major bridging operations were carried out.

During the retirement of the French army across the Weisse Elster after the battle of Leipzig, the French Engineer Colonel Mortier received orders to blow up the bridge across that river after all the French forces had passed over. During his temporary absence to ask for more precise instructions, a sapper corporal blew up the bridge prematurely. Large bodies of the French rear-guard were thus cut off and compelled to surrender to the Prussians.

One outcome of the defeat of Leipzig was that 150,000 veteran troops, forming the garrisons left behind in German fortresses, were lost to the French. Timely orders might have enabled some of these to be withdrawn. Only four fortresses capitulated in 1813, ten others held out till 1814, some of them till the declaration of peace.

Wartenburg. October 3rd, 1813. By Colonel Heye.

On the eve of the battle of Wartenburg, three field companies were busily employed

in bridging the Elbe by the village of Elster. They were the 3rd Field Pioneer Company of the IIIrd Prussian Corps (von Bülow), and the 1st and 2nd Field Pioneer Company of Yorck's Corps.

General Bertrand was holding a position on the left bank of the Elbe. The Prussians, on the right bank, resolved to attack with Yorck's Corps. General Gneisenau himself selected the point of crossing. The site was ideal from many points of view: a re-entering bend towards the attacker, commanding ground on the attacker's side, and firm banks, not too far apart. But no one had reconnoitred the enemy's side, which turned out to be marshy and cut up by ditches and spill-channels from the Elbe. The enemy's inactivity led Gneisenau to suppose that the French position was only weakly held.

The bridge, 160 metres long, was erected during the night of October 2nd/3rd. The piers consisted of boats in mid-stream, and four-legged trestles at the shore ends. It was completed at day-break on the 3rd. The pontoon column of the Russian corps arrived at Elster on the night of the 2nd, and, with its superior equipment, a second bridge was thrown across the river upstream of the Prussian one.

The Prussians began to cross the river at 7 a.m. After severe fighting, they succeeded in turning the enemy's position, and, in the afternoon, the French retired along the bank of the Elbe.

In this battle, insufficient use seems to have been made of the Engineers to enable guns to cross the ditches and other obstacles impeding their advance.

Construction of an Air-Raid Tunnel. By Captain Liebach.

One of the large Rhenish industrial concerns recently applied for the services of an Engineer company for the construction of an air-raid shelter to hold 500 men. The work was undertaken by the 2nd Company of the 34th Pioneer Battalion.

The site selected was the rock face of a ravine some 27 metres (about 90 feet) high. Two headings were driven into the rock, 26 metres apart, and the two tunnels were eventually connected, the whole forming an irregular hexagon in plan. In cross-section the tunnel was 3·50 metres wide and 2·50 metres high; the vertical sides being surmounted by a semi-circular vault. The formation of the hillside was mainly clayey slate, with veins of quartz running through it, and the strata were tilted at an angle of 60° to the vertical. The tunnel was unlined, except for a short length at each portal. The portals were at different levels; the bed of the tunnel was sloped upwards at gradients of 2% and 4·2% respectively to allow for drainage of seepage water.

Bore-holes were driven into the rock by means of compressed air hammer-drills, to a depth of 1 to 1·5 metres. Charges were kept small (0·4 kg. = 14 oz.). The explosives used were "romperite," "donarite I," or "gelatine donarite," according to the hardness of the rock. In spite of the small charges used, cracks were formed, and large pieces of rock were loosened in the roof.

The spoil was run out in tip-trucks on a field tramway and tipped off a raised platform into lorries. In order to clear away dust and fumes after the charges had been fired, a system of exhaust ventilation was installed, extracting 20 cubic metres of air per minute. In five minutes' time the workers could return to the tunnel.

At each portal, in the lined portion, two sets of doors were introduced, forming a gas-proof seal for the interior of the tunnel.

Sectional Exercises during Recruit Training. By Captain Meltzer.

A series of schemes for training recruits in simple tactical exercises.

Contemplations during the March into Sudetenland.

Major von Ahlfen describes his personal experiences during a journey into Sudetenland in a motor-van at the time of its occupation by German troops between October 3rd and 9th. The article is illustrated by 20 photographs showing Czech defences and bridge demolitions.

The Czechs made a thorough job of the demolition of bridges, big and small, on the main roads leading through Sudetenland, and did not spare explosives. These

demolitions would have hampered the advance of an army very considerably. Even the destruction of small culverts would have caused long delays. On the other hand, branch roads were not blocked, and the writer had no difficulty in getting through in his motor-van by making use of side roads.

In wooded country, wire entanglements and abatis had been erected, some of them evidently in a hurry, as they offered only a slight obstruction.

On October 6th the writer came across a bow-string girder, of reinforced concrete, across the Bicle river. It had been demolished by heavy charges near the points of support of both upper and lower booms, and had collapsed into the river. Major von Ahlfen suggests that if the bridge had not been fractured in one place in both lower and upper booms, it would have fallen obliquely to the axis of the bridge. The bridge would then have been more difficult to use for the passage of infantry; it would have been impossible to build a temporary bridge alongside; the removal of the broken bridge would have been rendered difficult, and a quarter of the explosives used would have been saved.

On the same day he came across a tunnel, in which the demolition had miscarried for want of proper tamping; he also saw a steel bridge, which had been blown up so as to fall obliquely, a position which made the construction of a temporary bridge very difficult.

Seven photographs illustrate various types of modern concrete defences and obstacles. Machine-gun posts were all built on the same pattern, with loopholes on either flank for firing to right and left, besides those for frontal fire. Walls and roofs were of reinforced concrete 2 to 4 metres thick. The roofs were extended to project over the loopholes. Machine-guns and anti-tank guns fired from armoured turrets. Observation was also carried out from armoured turrets. Holes were provided low down in the walls for throwing out hand-grenades.

Entanglements were made with hollow, square, iron posts, filled with concrete, so as to offer resistance to tanks. In some cases V-shaped ditches were provided with unequal sides, the steeper face being revetted with concrete, forming an effective obstacle to tanks.

Constructing an 8-ton Temporary Bridge with Floating Supports.

Lieut. Linke gives details of the construction—by the 2nd Company of the 32nd Pioneer Battalion—of a floating bridge to carry 8-ton loads across a canal taking off the Oder.

The available material consisted of river barges and squared timbers. The span from bank to bank was 42 metres, the banks were stony and the bed sandy. The velocity of the current was 0·30 metres (approx. 1 ft.) per second. The barges were 20 to 25 metres long, 3 to 4 metres wide, with a free-board of 0·80 to 1·10 metres and a carrying capacity of 30 to 42 tons.

Five possible alternative methods of construction were considered. That eventually adopted was the erection of a central saddle in each barge, with road-bearers running from saddle to saddle, without bearing on the gunwale. Details are made clear in a number of sketches accompanying the article.

Five barges and two trestles were used as supports. Most of the spans were 5·50 metres, the shore spans slightly less. Six road-bearers were used, 26 cm. x 26 cm. in section, spaced at 0·67 metre centres. The saddle-beam was 20 cm. x 20 cm. in section.

The bridge was built in four hours, and was tested and found capable of carrying 12-ton loads.

Railway Demolition in Volhynia by Aircraft.

In August, 1916, when the Russians were making vigorous attempts to reach Lemberg, the Germans determined to make a breach in the railway that formed the main line of communications in rear of the Russian forces. An officer (Lieut. von Cossel) was dispatched by aeroplane to a point some 70 km. behind the Russian main line. In order not to attract attention, the aeroplane dropped him at day-

break some six miles from the point selected on the railway. Carrying a 90-lb. load, which included an exploder and the requisite explosive charge, he marched for 12 hours through dense forest, and reached his objective at dusk. Under cover of darkness he placed the charge, and fired it as a train passed, derailing the engine and some ten loaded trucks. Removing the wires, and leaving a copy of *The Times* in their place, to mystify the Russians, he returned by road to his starting-point, where he was again picked up by the aeroplane.

Alexandrovka. By Major-General von Held.

In 1812, King Frederick William III of Prussia formed singing choirs, from Russian prisoners of war, which were attached to the 1st Guard Regiment. The number of these men gradually dwindled until, in 1826, there were twelve of them left in Prussia. The King, who took a special interest in them, started a colony for their benefit, known as the Alexandrovka colony. Special officers were detailed to build farmhouses and a chapel for them. The writer comments on this waste of men and money, at a time when all the efforts of the country were needed in the wars of liberation.

Ice Sailing.

Lieut. Lenkeit is an enthusiast for ice-sailing, a winter sport that is at its best in East Prussia, where the frosts are severe, but the ice is not spoilt by excessive falls of snow, as is the case in more northerly Baltic countries. He explains the necessity for having one's yacht in first-rate trim, and the skill required to get the maximum speed out of one's yacht. As in sea yachting, there are different classes of yachts, but a sail area of 15 square metres has been proved to give the maximum speed.

A.S.H.

WEHRTECHNISCHE MONATSHEFTE.

(*October*, 1938.)—*The Out-turn of Munitions in the United States during the World War.* By Dr. von Minden.

The information in this article is mainly obtained from various publications by Mr. Benedict Crowell, formerly Under-Secretary of State for War, viz., *The Giant Hand, The Armies of Industry, America's Munitions*, 1917/18, and others.

The exports from the United States to the Allied countries rose by leaps and bounds from August, 1914, until the entry of the United States into the World War in April, 1917. From July, 1917, to July, 1918, there was a distinct drop, followed by another rise which continued until after the end of the war.

The Allies' hopes that, with the entry of the United States on their side, the war would be over in a few months, were doomed to disappointment. In the first three years of the war, European countries had learnt by bitter experience the difficulties of changing over their armament works from peace to war conditions. The United States failed to profit by their experience. Months of delay occurred before explosives, machine-guns, howitzers and heavy guns were turned out in sufficient quantities.

It was not until the beginning of 1918 that an Inter-Allied Ordnance Agreement was concluded, to determine what munitions were to be supplied by the United States, and what Britain and France would supply for their own use and for that of the American Expeditionary Force. A series of tables are given in the article, comparing the out-turn of the various classes of munitions in Britain, France and the U.S.A. between April 1st, 1917, and November 11th, 1918. In rifles, machine-guns and smokeless powder the Americans were well ahead of their allies, but in other respects behind them.

Criticism is directed to the fact that, for six months, American democracy did not dare to introduce a control with full dictatorial powers over its armament works. When in full swing, their out-turn progressed in a way that excited the world's admiration, but it was six months behind time.

Mineral Treasure and Mines of Czechoslovakia. By Dr. Friedensburg.

This article was written before October 1st. Czechoslovakia's mineral wealth consists mainly of coal (both bituminous and brown) and iron ore. Most of it has now been absorbed by Germany.

Employment of Radio Apparatus in China. By Captain Oehme.

With the reorganization of the Chinese army some ten years ago, a simple portable radio apparatus of American pattern was introduced. It did not, however, prove satisfactory.

Latterly, a German apparatus has been adopted, suitable for pack transport. It will stand rough treatment and the vagaries of the Chinese climate, *i.e.*, damp heat, dust storms, etc. There are not enough specialists, either to work the radio, or as instructors, but the Chinese soldier has proved adaptable, and has succeeded in learning to use the instrument, which is remarkably foolproof.

Are Britain's Measures Sufficient to Ensure a Supply of Oil in the Event of War? By Dr. Ruprecht.

Britain is the largest consumer of oil in Europe. Out of twelve million tons used last year, only six million were obtained within the Empire. As practically the whole of her supply is obtained overseas, and is liable to be interfered with by hostile submarines and aircraft, she has collected a substantial reserve of oil in the country, and has made a start with the liquefaction of coal.

But, so far, only one plant has been installed on a large scale, *i.e.*, at Billingham. This plant has cost £8,000,000 : its maximum output is 150,000 tons, or 45 million gallons, viz., 3·75% of the present peace requirements. In order to keep pace with the latter, twenty installations, at least, are required, each costing £10,000,000. To the cost of £200,000,000 so arrived at, must be added another £50,000,000 as the difference in price between natural and synthetic petrol.

The question of rendering the country independent of imported petrol was investigated early in 1938 by the Falmouth Commission, who reported against the proposal. For the cost of the Billingham works 32 tankers could be built, which could deliver twelve times as much oil in a year as the Billingham works could produce.

It is suggested, however, that the Falmouth Commission has only considered peace conditions, and has not taken sufficiently into account what would happen in war-time, when the consumption of oil may be quintupled. In the year 1936 the world's oil supply amounted to 247 million tons, of which the Great Powers took 186 millions. Out of the latter the U.S.A. took 139 millions, and the European powers 43 millions.

Should the world be involved in another general conflagration, the U.S.A. alone might require 700 million tons ; other countries would increase their demands in proportion. The price of oil would then reach a fabulous figure, and it is possible that synthetic oil might be cheap in comparison with natural oil.

In the writer's opinion, Britain is taking considerable risk in not increasing her plant for the liquefaction of coal : her dependence on foreign imports is a source of weakness.

(*November*, 1938.)—*Armament and Industrial Preparations in Great Britain.* By Hans Hagen.

The writer introduces his subject by a reference to a British white paper published on March 3rd, 1936, which marked a turning-point in British policy. It was found necessary to carry out a further reorganization of the air arm, to modernize the navy and army, to provide reserves of food and equipment, and to organize the industrial capacity of the nation.

Figures are given showing the steady increase in naval construction between 1935 and 1938. As regards the army, extensive motorization and mechanization have been carried out. Woolwich arsenal has been extended. Additional factories have been erected for the provision of arms, ammunition and gas-masks. The air force has

been expanded by 150% in three years, and there has been a great increase in the out-turn of aeroplanes.

The writer goes on to describe the " shadow " industry, the organization of civil industry for war purposes, and, finally, the organization for the defence of the country. Britain is now in a position to exercise a very powerful influence in the European balance of power.

Italy's Policy with Regard to Minerals for Industrial Purposes. By Dr. Friedensburg.

Of all great military powers, Italy is the most unfavourably situated with regard to mineral raw materials. With the exception of sulphur and zinc, mercury and aluminium ore, she has no large supplies of any of the important minerals.

The writer has prepared a table showing the countries from which Italy derives her most important mineral products. These are, as regards the main supply: Germany, for coal and coke; the United States, for crude oil and iron scrap; Rumania and Venezuela, for fuel oil; Spanish Morocco, for iron ore, etc.

Endeavours have been made to increase the petrol supply by the hydrogenation of coal; a small quantity of shale oil is found in the northern Apennines. Fuel alcohol is obtained from agricultural products, and the use of producer gas is encouraged. The water supply of the country has been exploited to the fullest extent for hydro-electric purposes. Italy has been enabled, at very great expense, to reduce her dependence upon foreign countries for imports, but, for the greater part of her mineral requirements, she must necessarily fall back on foreign imports.

Japan's Industry in War-Time. By Dr. Schoene.

The war that Japan is now conducting in China is by far the most expensive she has ever waged. Its cost is met partly by extra taxation, and partly by borrowing. Japan's armament industry is controlled by Government, and has made large strides in recent years. But the country is badly placed in regard to raw materials. Practically all metals have to be imported, as well as the whole of her rubber, raw cotton, and wool supply. She is not likely to run short of food: her main foodstuffs are fish and rice, both of which can be obtained locally. Japan is, however, heavily handicapped owing to her armament industry having been mobilized late in the day.

Contracts and Shadow Factories. By Dr. Ruprecht.

A sketch of the British shadow factory system, from an American point of view. The criticism, on the whole, is favourable, but it is pointed out that the cost, both original and for maintenance, is high.

Popular Education in Industrial War Work. By Dr. Leonhardt.

A plea for the education of the working classes in industrial war work. It is common knowledge that the whole industrial system of the country will be revolutionized on the outbreak of war, but very few people have any idea of the work that they will be called upon to do in war-time. The writer stresses the importance of educating the public in their duties by propaganda and publicity of a popular kind.

The Science of Gunnery 250 Years Ago.

A brief review of a 16-page book published in 1713, before anything was known of ballistics.

(*December*, 1938.)—*The Land Fortifications of Czechoslovakia.*

No European country has ever been in a more difficult position for defence, commerce, and administration than Czechoslovakia during the years 1918 to 1938. Its length from west to east was, roughly, 900 km., its average breadth was 160 km., while Carpathian Ruthenia, the eastern end, was only 40 km. wide. In comparison with France, the ratio of perimeter to area was six times as great.

The problem of its defence was based on the assumption that, in the event of a German attack, it should be able to hold out until its allies, France and Russia, came to its aid.

With the help of a map, the writer of the article takes us all round the defences of the country. This presents no difficulty, since the majority are now in German hands. The front line defences were practically complete and capable of being held. But only a small portion of the rear fortifications were ready and fit for defence. It is estimated that 200 to 250 works with armoured turrets, and 8,000 to 10,000 machine-gun posts have been built, besides obstacles and blocking devices. The cost incurred for works only is reckoned to be 800 million R.M. (say £70,000,000). The force required to man the defences over a length of 4,000 km. would be about 720,000 men, and would absorb the whole Czechoslovak army, leaving no field army whatever.

The writer thinks that the Czechs would have done better to prepare a strong defensive position on the Morava river, and perhaps another round Prague, to serve as *points d'appui* to the field army. It is suggested that the system followed was selected because it provided numerous air bases for operating against German industrial centres.

Modern River Crossings and the Means of Effecting Them. By Major-General Klingbeil.

A new German bridging equipment was introduced in 1910, and was mainly designed for bridging and not for ferrying purposes. In 1914 every division was equipped with a bridging train consisting of 12 half-pontoons, capable of being made up into six whole ones. A corps possessed a bridging train of 26 whole pontoons. A half-pontoon weighed about 300 kg. and could be carried by 10 men; a whole pontoon weighed 500 kg. and required 18 men to carry it.

A drawback to the equipment in use during the war was the time wasted in taking the pontoons out of bridge and using them for ferrying. The absence was felt of light portable ramps for loading horses and vehicles, and the motorizing of pontoons was unknown.

The first task to be carried out when forcing a river passage is the driving back of the enemy scouts. This should be done with boats, carrying, in addition to the crew, either six to eight rifle-men, or else a machine-gun detachment, or an infantry gun. The most suitable apparatus for the purpose is the kapok raft: it is light and portable and not easily sunk. For horses and vehicles not exceeding four tons in weight; some form of light bridging equipment is necessary that can move across country. For heavy vehicles, guns and ammunition, heavy bridging equipment will be required.

It is doubtful whether it will be possible to maintain bridges by day. Ferrying will probably be the only means of crossing a river in daylight; bridging will have to be confined to the night.

War Industry Potential.

Dr. Leonhardt defines the title of his article as a combination of industrial conditions and possibilities of development that a nation can utilize for war purposes. The subject is considered under the following headings: (1) raw materials, (2) manufacture, (3) population, (4) transport, (5) finance.

It is obvious that with the outbreak of war the productivity of a country must diminish. The world production of coal, metals, oil, rubber, foodstuffs and textiles dropped by 8% during the war years. It is interesting to note that the supply of munitions with which Germany entered the war was practically exhausted in 1½ months.

Britain's Oversea Dominions and their Armament.

Dr. Ruprecht describes the part that the Dominions are taking in their own defence and in that of the British Empire.

An effort is being made to make Australia and New Zealand the armament factories for the British Empire in the Far East. Both Dominions have large resources in coal, iron ore and manganese, as well as in non-ferrous metals. Armament and explosives manufactories are being installed.

South Africa has large supplies of coal, manganese and iron ore. The financial interests of the country have hitherto been wrapped up in gold and diamond mines. Coal and iron are comparatively new ventures, backed by Government. The manufacture of war-like stores is now being undertaken on a large scale. Arrangements are being made for the manufacture of tanks, aeroplanes and heavy lorries; and the construction of a plant for the liquefaction of coal is under consideration.

Canada and Newfoundland are on a different footing from the other Dominions. They need hardly reckon with the possibility of a hostile attack. But they possess a very considerable mineral wealth, which, in the event of war, would be placed at Britain's disposal.

India has a large supply of minerals useful for war purposes, but her chief asset is her man-power. She is quite capable of defending herself against a hostile attack, as well as of furnishing men and materials for the defence of outlying parts of the Empire.

Britain will, in future, have to bear the main share of the burden of the defence of the Empire, but her possible adversaries will have to reckon with the fact that the British Empire is not merely politically united, but is an organized military unit.

Points of Passage through the Vosges Mountains.

Dr. Mouths refers to an article in the September, 1937, number of this magazine (*W.M.*) in which the construction of two tunnels through the middle Vosges mountains was described. These two tunnels complete two connecting links by railway between the great fortresses of Strassburg and Epinal.

In this article he refers to two other projects for establishing connection through the southern Vosges mountains: (1) a line from Cornimont through Metzeral to Colmar, (2) a line from St. Maurice (in the upper reaches of the Moselle) to Bussang, through the Col de Bussang to Thann and Mülhausen. The latter line was begun, but was held up for various reasons in 1935. The completion of both lines is now being pressed for.

A.S.H.

THE INDIAN FORESTER.

(*September*, 1938.)—*Studies in the Ecology of the "shola" Grassland Vegetation of the Nilgiri Plateau*, in spite of its rather alarming title, is fortunately not too technical for the lay-reader. We learn that the English gorse, which was introduced there some short time ago as a decorative shrub, is spreading and becoming rather a nuisance. Not so the yellow broom, another exotic, which has established itself but is not extending its holding. A theory of the damaging effect of frost is put forward, namely, that it is not so much frost that kills plants, but a sudden thaw after frost.

An ingenious method of treating fence posts with preservative (*Ascu* is that used) is to slip an old inner tube on to the head of a newly-felled post, with the free end supported so that it can hold the Ascu. The sap drains out first at the foot of the post, and when it is followed by the first of the Ascu, the degree of the impregnation is considered to be sufficient, and the post is removed and dried. It remains to be seen how long the posts will last, but from experiments in the U.S.A. with another preservative, it seems that the life of a post so treated will be of the order of 10 to 15 years.

A record elephant has been shot, apparently in Bengal, by Mr. Gyles Mackrell, of Messrs. Octavius Steel & Co., of Calcutta. Here are the measurements:—

Height, 10′ 9½″.
Tusks, 6′ 0½″ and 4′ 11½″, the latter broken.

It may be added that the animal was a rogue and had killed several men.

(*October*, 1938.)—Mr. Sinha describes the very efficient way in which timber is

exploited in Finland, where it is the chief industry. At one mill he saw forty different sizes of scantlings being sorted by a machine; one man pressed the button, and the scantlings travelled suspended, to various distances, and fell into their own enclosures, like letters in a linotype machine. The chief varieties of timber are the Scots pine, spruce and birch. There is little likelihood of exhaustion of the forests, as the trees regenerate naturally.

"Tiger Census" records the results of enumeration carried out in the Palamau division of Bihar. A tiger fills in his census paper by recording his footprint in the neighbourhood of a water hole, the positions of all of which in a particular area are known. As he drinks only once a night, there is no chance of duplication if the pugs are counted and measured the next morning. From the footmark, the sex, size and direction of movement of the animal can be told, if not the other particulars required in the case of a human census.

(*November*, 1938.)—Soil erosion, not only in India, but in almost all parts of the world except Europe, is the subject of two articles. Over-cultivation, over-grazing and deforestation are the principal causes. The first of the two articles, by Dr. Maclagan Gorrie, refers to severe erosion in the Uhl valley above the Mandi hydro-electric plant (built by Battye of the Corps) owing to potato farming on unterraced land and to the over-stocking of grazing grounds. It is to be hoped that mankind will grow "erosion-conscious" before a major famine sets in.

(*December*, 1938.)—This number is unusually full of natural history. An article on elephants relates how a female ran into the jungle shedding tears, as she was unable to stand the sight of her dying cub. The main purpose of the narrative is, however, to record two authenticated instances of twins being born to she-elephants.

The second article, on carpenter bees, is by Mr. Beeson, the Forest Entomologist. These bees are apt to be a nuisance, as they make tunnels in timber, an inch in diameter, and four or five inches long, for laying and hatching eggs.

Finally, an account of a man-eating tiger, relates how, in three months, one killed seven villagers in North Kanara, terrorizing the district until shot by a forest ranger.

F.C.M.

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